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SOUTH WALES MINING EXAMINATION.—PAGE 436.

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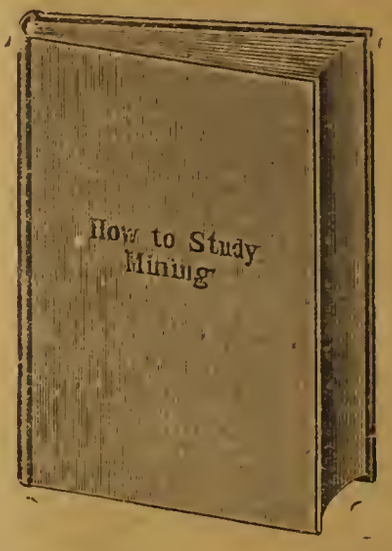

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NEWS AND NOTES.

Overwinding Prevented by Safety Appliance

Following upon the "gob-fire," which caused such an extraordinary sensation recently, there was another mishap at the Hickleton Main Colliery. During the process of drawing coal, the engineman at one of the shafts would have over-wound the cages but for the patent safety appliance (which is the Hickleton Main Company's own design, and which has been in use at this colliery for about two years). This appliance caught the rising cage firmly, and at the expense of a good deal of damage to the top compartment stopped the over winding. The damage temporarily interfered with the drawing of coal, but prevented a much more serious accident. At the same time, had the appliance failed to act there was still a mechanical arrangement in reserve which would have probably prevented the overwinding.

German Coal Trade.

The import of British coal into Germany shows a decrease from 9,650,000 to 9,420,000 tons. The difficulties of German inland navigation in 1911 were, no doubt, to some extent responsible, says a Consular report, yet it is to be expected that the developments of recent events upon the German coal market and the construction of more efficient waterways, especially by way of the Baltic, will help to make the decrease of 1911 only a temporary one. The total export of German coal rose by 3,150,000 tons, the export to the United Kingdom, which is never considerable, receded by 1,700 tons. The progress made by German coal in Egypt is worth noting; this export amounted to 160,000 tons, thus rising in 1911 by over 66,000 tons. The increase of coal furnished to foreign ships in German ports is also remarkable; it rose from 186,000 tons in 1910 to 236,000 tons in 1911.

Board of Trade Labour Statistics.

The Board of Trade *Labour Gazette*, in an article on the state of the Labour market in March, says: Employment in all industries was affected by the coal strike. In the pig-iron and steel, tinplate, pottery, glass, and brick trades the effects of the dispute were felt at an early date, and became increasingly marked with each successive week. Employment in connection with railways, shipping, and docks was also seriously reduced. The influence of the strike was less marked in the cotton, hosiery and lace trades, while the linen and shirt and collar trades even showed improvement as compared with a month ago. The jute industry had a dispute of its own at Dundee. Compared with a year ago most of the principal industries showed a decline, due to the coal strike, but in the cotton, lace, and boot and shoe trades there was improvement. In 392 Trade Unions, with net membership of 675,535, making returns, 76,144, or 11·3 per cent., were returned as unemployed at the end of March, 1912, compared with 2·8 per cent. at the end of February, 1912, and 3 per cent. at the end of March, 1911. The great dispute in the coal mining industry, involving about a million workpeople, began on March 1st and continued throughout the whole of the month and early part of April. The total number of workpeople involved in all disputes in progress during the month was 1,040,542, as compared with 164,650 in February, 1912, and 46,577 in March, 1911. The estimated aggregate duration in working days of all disputes in progress during March was 24,579,500, as compared with 463,500 in the previous month, and 723,800 in the corresponding month of last year.

Big Output of Coal.

The approximate output from the collieries of the Dominion Coal Company for March will be 353,000 tons, an increase of about 21,927 tons over the February output. The output in February was 330,073 tons, and in January was 280,854. The total output for the company for the year up to the present is about 975,000 tons, which is a great increase over the amount up to this time last year.

Engineering Imports and Exports.

The Board of Trade returns show that during the first three months of this year the imports of iron and steel and manufactures thereof amounted to £2,909,896, or £113,114 more than in the corresponding period of last year, while the exports reached the value of £12,339,318, an increase of £1,290,926. The imports and exports of other metals and manufactures thereof were £7,673,152 and £2,852,605, which, compared with last year, show increases of £1,058,711 and £159,757 respectively. The imports of electrical goods increased by £53,711, and the exports by £493,416, the totals being £411,261 and £1,190,738. The imports of machinery amounted to £1,632,483, an increase of £169,944, and the exports to £7,812,470, an increase of £332,585. Ships (new) were imported to the value of £10,867, a decrease of £32,654, and were exported to the value of £1,175,729, an increase of £56,125. During the month of March alone substantial increases are shown to have occurred in the imports of all the above classifications, as compared with March of last year, with the exception of iron and steel and manufactures thereof, in which case a loss of £218,906 is recorded. In the exports increases took place in connection with iron and steel (£579,899), electrical goods (£394,060), and machinery (£33,733); decreases are shown in connection with other metals and manufactures thereof (£9,329), and ships (£34,742).

A Compensation Bill.

The following is the text of the Compensation for Mineral Damage (Scotland) Bill introduced in the House of Commons by Mr. Duncan Millar, and backed by Sir H. Dalziel, Sir W. Menzies, Mr. Hodge, Mr. Murray MacDonald, Mr. Pringle, and Mr. Whitehouse: A bill to amend the law relating to feus and leases for building in Scotland and to secure compensation for injury caused by mineral workings. (1) Subject to the provisions of this Act, where land shall be or has been feued or let upon the condition that buildings are or were to be erected thereon, any contract or agreement purporting—(*a*) To entitle the superior or lessor to do any act whereby the buildings may be injured which but for such contract or agreement he would not have been legally entitled to do without making full compensation for the injury thereby caused; or (*b*) to release the superior or lessor from any obligation to pay damages for doing injury to such buildings which but for such contract or agreement he would have been liable to pay; or (*c*) to bind the feuar or lessee to accept any compensation or damages less than full compensation for the injury actually caused, shall be void. (2) Where prior to the passing of this Act land has been feued or leased for building subject to any such contract or agreement as aforesaid, it shall be lawful for the superior or lessor at any time within six months after the passing of this Act to resume possession of the land with the buildings thereon on payment of their value. (3) The parties, if they do not agree upon the value, may jointly appoint an arbiter, whose decision shall be final; or each party may appoint an oversman, whose decision shall be final. (4) The value shall be estimated as if no such contract or agreement had been made. (5) This Act may be cited as the Compensation for Mineral Damage (Scotland) Act, 1912.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q.—*Describe the "Winhey" arrangement for breaking the circuit when a leakage occurs in the D.C. system.*—(*Submitted by* W.P.)

A.—The principle upon which the Winhey leakage detector acts, according to Mr. Robert Nelson, H.M. Electrical Inspector of Mines, is that "the earthing of the neutral point of the generator is made through a resistance so high that, in case of accidental contact with live metal by any person, the resulting current to earth passing through the person making contact is so small in quantity as not to be dangerous to life."*

The apparatus is the invention of Mr. Walter Winsborough, and Messrs. Heyes and Co., of Wigan, are the makers of the instrument. It consists of a trip relay, operated by a detector through a local battery. A 230-volt circuit operates the trip. The trip breaks the knuckle joints of a pair of Reyrolle triple-pole circuit breakers controlling the main cables. In the case of a person coming into contact with any live part, such as switchgear, terminals, faulty cables, machine frames, &c., protection is afforded the person by the detector operating by a current which flows through the body before it has had time to contract the muscles of the person; the current operating being just sufficient to give an appreciable shock as a warning.

Its scope of usefulness, so far as we have gathered, seems to be somewhat limited. It cannot be used on any high-pressure system, say of so high a tension as 2,000 or 3,000 volts. Its usefulness seems to be limited to the medium-pressure system of 500 to 600 volts. With the higher tension the normal leakage current is such as would in many cases produce fatal results in itself. One of the chief objections to the use of the Winhey leakage detector is that should a fault occur bringing the device into action, the whole installation is at once disconnected, which in the case of a large system will be a serious matter. The tripping circuit might be arranged to produce only the shutting down, or disconnection, of the underground portion of any mining system, leaving the surface portion alone, but even that is at the least inconvenient, and may possibly be dangerous. There is no doubt at all that if a leakage should occur through short-circuiting in any portion of a system in the mine, that portion should be shut down until the fault is removed, and it would be a decided advantage to bring that portion of the system to rest suddenly before serious results occurred, but for that purpose any leakage detector should be capable of being installed on each separate feeder to ensure disconnection of the faulty feeder only.

Q.—*The return air of a mine shows by analysis* $1\frac{3}{4}$ *per cent. of fire-damp. The volume is 100,000 cubic feet per minute, and the water-gauge in the fan drift is* $2\frac{1}{2}$ *inches. Find* (a) *the volume of air required to reduce the quantity of fire-damp to 1 per cent.;* (b) *the additional horse-power required from the fan to circulate the increased volume.*—(*Manchester District Examination, First Class*).

A.—It is, of course, assumed that the volume of 100,000 cubic feet passing through the return is inclusive of $1\frac{3}{4}$ per cent. of fire-damp, and hence this volume will be made up of air and fire-damp. The volume of fire-damp present in the total volume of mine air may be found by simple proportion:—

As 100 per cent. : 1·75 per cent. : : 100,000 cubic feet : 1,750 cubic feet.

The volume of fire-damp passing per minute, then, is 1,750 cubic feet, and the volume of *air* passing in addition to the fire-damp is 100,000 — 1,750 = 98,250 cubic feet. Now, the volume of fire-damp passing per minute remains constant, whilst the volume of air is increased until the proportion of fire-damp in it is decreased to 1 per cent., hence, the total volume now passing will be 1,750 × 100 = 175,000 cubic feet. The first measured volume is 100,000 cubic feet per minute, the total required volume to reduce the percentage of fire-damp to 1 per cent. is 175,000 cubic feet per minute, hence (*a*) the volume of air required to reduce the quantity of fire-damp to 1 per cent. is such as will give a total *measured* quantity of 175,000 cubic feet per minute.

The horse-power in the air is found by the formula:—

$$\text{H.P. in air} = \frac{\text{W.G. in ins.} \times 5{\cdot}2 \times Q}{33000}$$

Where Q = quantity of air passing in cubic feet per minute. To circulate the first quantity,

$$\text{H.P.} = \frac{2{\cdot}5 \times 5{\cdot}2 \times 100000}{33000} = 39{\cdot}39, \text{ or say } 40 \text{ H.P.}$$

(*b*) The additional horse-power required from the fan to circulate the increased volume may be found in two ways; first, by formula above, for which the increased water-gauge will be required; second, by simple proportion.

(1) *Increased Water-Gauge.*—The ventilating pressure, and consequently the water-gauge, varies directly as the square of the quantities passing, therefore, by proportion

As $100{,}000^2 : 175{,}000^2 : : 2{\cdot}5$ inches : x inches.

$4^2 : 7^2 : : 2{\cdot}5 : x.$

$\therefore 16 : 49 : : 2{\cdot}5 : x.$

$$\therefore x = \frac{2{\cdot}5 \times 49}{16} = 7{\cdot}656 \text{ inches.}$$

$$\text{Then, H.P.} = \frac{7{\cdot}656 \times 5{\cdot}2 \times 175000}{33000} = 211{\cdot}12.$$

(2) *By Simple Proportion.*—Rule, power varies directly as the cube of the quantity, then,

As $100{,}000^3 : 175{,}000^3 : : 40$ H.P. : x H.P.

$4^3 : 7^3 : : 40 : x.$

$$\therefore x = \frac{343 \times 40}{64} = 214 \text{ H.P.}$$

Since we have approximated from 39·39 H.P. in the first instance to 40 H.P., the calculated H.P. in the second case will be about 212 H.P.; the *additional* horse-power required then from the fan to circulate the increased volume is

212 — 40 = 172 H.P.

Q.—*It is proposed to wind 1,000 tons per day of eight hours from a shaft 400 yards deep, the ropes being balanced. The ventilation required is 150,000 cubic feet per minute, at an estimated water-gauge of 3 inches. The power plant during winding hours generates an average of 600 k.w., and supplies power for all purposes, other than for winding and ventilating. Give the approximate brake horse-power of* (a) *the winding engine,* (b) *the fan engine;* (c) *generating engine, and state what steam pressure, and what size, type, and number of boilers you would adopt.*—(*Manchester District, First Class, and submitted by* RESOLVEN).

A.—The boiler power must be sufficient to deal with the maximum load, or give the maximum power required, at any time, and therefore the approximate total horse-power, plus a reserve power, will have to be calculated, capable of keeping the whole plant fully equipped at the same time.

(*a*) *The Winding Engine.*—Assuming the "eight hours" per day mentioned in question to be the time actually spent in winding coal, then the number of tons to be wound per hour $= \frac{1000}{8} = 125$ tons.

It is next required to ascertain the time occupied per wind. An excellent rule for ascertaining the mean cage speed in feet per second is given by Mr. T. A. O'Donahue, in his *Mining Formulæ*, as Cage speed (mean) in feet per second = $10 + 5D$.

Where D = depth of shaft in hundreds of yards.

Therefore, according to above, the mean cage speed for a shaft 400 yards deep may be taken as $10 + (5 \times 4) = 30$ feet per second. If we allow, say, 20 seconds for banking decks, this means that the time occupied per wind $= \frac{1200}{30} + 20 = 40 + 20 = 60$ seconds per wind, or 60 winds per hour. (In many cases at a depth of 400 yards this speed of winding will be exceeded).

Since it is required to raise an output of 125 tons per hour, then $\frac{125}{60} = 2{\cdot}08$ tons per wind. The actual amount of coal raised per wind will, of course, depend on the capacity of the cage and the size of tub used; and, therefore, in order to provide

* Transactions Institute Mining Engineers, Nol. XLI, page 191.

for contingencies, &c., the amount here raised may be approximately stated at, say, 2½ tons, or 50 cwt. per wind.

Since the ropes are balanced, and under ordinary conditions the cages, tubs, chains, &c., are also balanced, the load against the engine per wind is really the weight of the coal. Hence, the useful work performed by the engine *per wind* is equal to the weight of coal in lb. × depth of shaft in feet; or, since the time per wind includes an allowed time for banking, the useful work performed by the engine per minute is equal to the weight of coal raised in lb. × speed of cage in feet per minute.

Therefore, useful work = 50 cwt. × 112 × 30 feet × 60 seconds, and H.P. available from the engine, or B.H.P.,

$$= \frac{50 \times 112 \times 30 \times 60}{33000} = \text{say, 306 B.H.P.}$$

To allow for acceleration of load, stoppages, &c., suppose we allow, say, 50 per cent. above the calculated B.H.P., making an approximate H.P. required for the winding engine of 306 + 153 = say, 460.

(*b*) *Ventilation.*—The brake horse-power of ventilation may be found by the following, viz.:—

$$\text{H.P. in air} = \frac{Q \times \text{W.G. in ins.} \times 5{\cdot}2}{33000}.$$

Where Q = quantity in cubic feet per minute, and W.G. = water-gauge in inches, hence,

$$\text{H.P.} = \frac{150000 \times 3 \times 5{\cdot}2}{33000} = 71 \text{ H.P.}$$

(*c*) *Generating Engine.*—The generating plant, during winding hours, gives an output of 600 kws., and since 1 k.w. is equal to 1,000 watts, this output equals 600,000 watts. One horse-power is equal to 746 watts, hence, an output of 600,000 watts $= \frac{600000}{746} = 804$ H.P., approximately.

The total actual brake horse-power required, then, is 460 + 71 + 804 = 1,335 H.P. But this is the *brake* horse-power, which is only a portion of the horse-power required from the boilers. It may be advisable, in order to allow for steam losses, power spent on wasted work in engines, emergencies, &c., to say that the approximately calculated H.P. is equal to about 70 per cent. of the power required, hence,

$$\text{Power required} = \frac{1335 \times 100}{70} = \text{say, 2,000 I.H.P.}$$

Since the boilers will be placed close to the engines, a boiler pressure of 100lb. per square inch will give an effective pressure on engines at 70lb. per square inch.

Assume the Lancashire type of boiler to be used, and that the size of each boiler is 30 feet by 8 feet. Such a boiler would have in round numbers about 40 square feet of firegrate area, and assuming the rate of combustion to be 18lb. per square foot of fire-grate area per hour, the quantity of coal burnt per hour for each boiler is 40 × 18 = 720lb. A boiler of this character should evaporate, with feed heater, 10lb. of water per pound of coal from 200° Fahr. Taking average conditions, however, say 9lb. of water evaporated per pound of coal, then 720 × 9 = 6,480, or, say, 6,400lb. of water should be evaporated per hour.

In practice the water evaporated is very variable, depending, of course, on the consumption of fuel, the quality of the fuel used, the conditions of the plant and mode of firing, the temperature of the feed water, &c. It is not surprising, therefore, that there seems to be rather a wide range of statements made as to what horse-power to expect from a boiler.

One rough and ready rule for determining the nominal horse-power of a Lancashire boiler "in common use among colliery managers, engine-wrights, and others," is

$$\text{H.P. of Lancashire boiler} = \frac{\text{Diameter}^2 \times \text{length}}{5}.$$

By this rule, given in *The Colliery Manager's Pocket-Book*, the H.P. of a 30 feet by 8 feet Lancashire boiler

$$= \frac{8^2 \times 30}{5} = 384,$$

Hence, for a total horse-power of 2,000, five boilers would not be sufficient, whilst *six* boilers would be sufficient, and give a surplus power, which might sometimes be required. This rule might be qualified by saying that a good engine will ordinarily use 16 to 18lb. of water per hour per horse-power, and since the amount of water evaporated per hour by a Lancashire boiler of this size is about 6,400lb., as shown above, then H.P. of boiler $= \frac{6400}{16}$ to $\frac{6400}{18}$, or 400 to 360, which covers above ready rule.

Mr. T. A. O'Donahue, in his *Mining Formulæ*, gives the amount of water evaporated per hour as 6,400lb., "and allowing 30lb. of water per I.H.P.," this gives practically 200 as the H.P. of the boiler for colliery purposes. Taking this as a basis, the number of boilers required would be $\frac{2000}{200} = 10$. In each case it is essential that an additional boiler should be provided in the nest of boilers to allow for any one of them being cleaned or repaired. Mr. O'Donahue says that "non-condensing engines require from 25 to 35lb. of water evaporated per indicated horse-power per hour, but 30lb. may be taken as the weight required by most non-condensing engines used at collieries, the winding engines being excepted, as these require 40, and in some cases 50lb., owing to the intermittent manner in which they have to work. The American Society of Mechanical Engineers has adopted as a standard horse-power an evaporation of 30lb. of water evaporated per I.H.P. per hour, though when working under the best conditions with superheated steam the weight of water has been reduced to nearly 10lb. per I.H.P. required per hour."—(*Mining Formulæ*, page 81).

A question of this character generally admits of several *approximate* answers. It is fairly easy to calculate the requirements of continuously running engines for ventilation and for generating electric power, but owing to the intermittent character of the winding engine, unless one takes into account the power required for acceleration, &c., his answer is apt to be very approximate, *i.e.*, he may be well above or under the actual requirements.

Q.—*The three sides of a triangle are 12, 20, and 28 yards; what is the area?*—(*Southern District, First Class*).

A.—The most common rule for finding the area of a triangle when the lengths of the three sides are given is:—

Area of triangle $= \sqrt{S\,(S-a)\,(s-b)\,(s-c)}$.

Where s = half the sum of the three sides, and a, b and c = the lengths of the sides respectively.

$a = 28$, $b = 20$, $c = 12$.

$$s = \frac{a+b+c}{2} = \frac{28+20+12}{2} = 30.$$

$s - a = 2$; $s - b = 10$; $s - c = 18$.

$\therefore$ Area $= \sqrt{s\,(s-a)\,(s-b)\,(s-c)}$.

$= \sqrt{30 \times 2 \times 10 \times 18}$.

$= \sqrt{10{,}800} = 103{\cdot}92$ square yards.

Another method is as follows:—

$$\text{Cos } C = \frac{a^2 + b^2 - c^2}{2ab} = \frac{28^2 + 20^2 - 12^2}{2.28.20}.$$

$$\therefore \text{Cos } C = \frac{784 + 400 - 144}{1120} = \frac{13}{14}.$$

$$\text{Sin } C = \sqrt{1 - \cos^2 C} = \sqrt{1 - \left(\tfrac{13}{14}\right)^2} = \sqrt{1 - \tfrac{169}{196}} = 0{\cdot}37115.$$

Area of triangle $= \frac{1}{2}ab \sin C = \frac{1}{2}.28.20.0{\cdot}37115 = 280 \times 0{\cdot}37115 = 103{\cdot}92$ square yards.

[NOTE.—In last issue, page 415, appears the statement: "To produce an atmosphere fit to breathe no free oxygen can be allowed," to which Mr. T. H. Byrom draws exception. Certainly, air is a mixture, and *all* the oxygen is free. What the sentence meant to imply was that the normal atmosphere contained 21% of oxygen, and any *excess* of oxygen would produce a too rapid action in breathing; therefore to produce a normal atmosphere no *excess* of oxygen can be allowed. The word *excess* would have been better than the word "free" in this case. I thank Mr. T. H. Byrom for pointing out the mis-statement.—TYKE.]

NOTES FROM WALES.

By BRYCHAN.

South Wales Mining Examination.

* Questions set at the Examinations for 1st and 2nd Class Certificates of Competency under the C.M.R. Act, 1887, South Wales Mining District, 1911.

FIRST CLASS CERTIFICATES.

Mines Acts.

1.—What is meant by a permitted explosive? State what is the composition of one. Write out the Explosives Orders bearing upon the following: (*a*) The absolute prohibition of certain explosives in fiery mines; (*b*) the conditional probibition of other explosives in fiery mines.

2.—What are the requirements of the Mines Acts in respect of the use of detonators?

3.—Write out the General Rules bearing upon the following subjects: (*a*) Feneing machinery; (*b*) safety-valves and gauges for steam boilers; (*c*) cover overhead; (*d*) chains.

Ventilation.

1.—What is your standard of ventilation in a fiery and dusty mine?

2.—What is meant by the term "*if the air contains either less than 19 per cent. of oxygen or more than 1¼ per cent. of carbon dioxide*"?

3.—Are there any advantages in installing the chief ventilating fan underground? Can the Mines Acts be complied with when the fan is placed underground?

4.—Assuming the quantity of air circulated in a mine to be 200,000 cubic feet per minute, with a barometer of 29 inches and thermometer 60° Fahr., how many tons of air passes into the mine in 24 hours?

5.—What use is a "Hygrometer" in an intake air-way near the shaft?

Surveying.

1.—What is meant by parallax, and how is it tested for and eliminated? Describe the adjustment for collimation in a theodolite.

2.—Of the Ordnance survey scales, one is the natural scale of $\frac{1}{2500}$; what is this in chains per inch, and what is meant by $\frac{1}{2500}$?

3.—Plot the following to a scale of 2 chains = 1 inch, the measurements to be reduced to the horizontal:—

(1) N40°E.	238 links.	Angle of dip	22°30′.
(2) N87°E.	325	,,	12°15′.
(3) S10½°E.	428	,,	16°25′.
(4) S20°25′W.	396	,,	19°30′.

Give the bearing and distance to join 1 and 4.

4.—In making an underground survey by loose needle you have to survey through a roadway in which at one point there are east-iron pipes on each side, causing the needle to be unreliable; how would you continue the survey past this point?

Geology.

1.—What is meant by the terms "Igneous" and "Aqueous" rocks, and "intrusive dyke"?

2.—Describe a "Clinometer" and its uses.

3.—Give a sketch showing "unconformable strata."

4.—What is meant by "outliers" and "inliers" when describing the outcrop of a seam of coal?

Machinery.

1.—What are the electrical units of current; of potential and of power, and how are they related?

2.—What is meant by using steam expansively, and what are its advantages? What is meant by the term "ratio of expansion"? Give an illustration.

3.—Give a dimensioned sketch, or drawing to scale, of a safety-valve to blow off at 81lb. to the square inch. The area of the valve is 6 square inches, and it is placed at 2 inches from its fulerum; the weight of the lever is 54lb.

4.—A slant opening in a steep measure colliery is 1,200 yards long, dipping at the rate of 12 inches to the yard. 600 men and boys have to be lowered into and raised from the mine daily. The hauling power at the slant head is a pair of direct acting haulage engines, cylinders 25 inches diameter, 15 inches stroke, and drum 10 feet diameter; steam, 100lb. per square inch. Give a full description, with dimensions, of the appliances you would employ, and state what special precautions you would take to avoid accidents or injury to the men.

How long would it take—

(*a*) To lower 600 men and boys?

(*b*) To raise them to the surface?

5.—At a pair of pits 378 yards deep it is intended to produce an output of 600 tons per eight hours day. The seam is 5 feet thick, and the trams carry 30 cwt. of coal each.

(*a*) Calculate the H.P. required in a pair of winding engines to meet the case.

(*b*) Describe the engines, and state what consumption of steam at 150lb. per square inch there would be per hour.

(*c*) State the number, and describe what class of boilers you would lay down to accomplish the work.

Practical Working.

1.—Describe the principle of the siphon, and state in what circumstances it may be beneficially applied for conveying water in mines. Give a sketch showing its application.

2.—Give the length of face required for the employment of 350 colliers in—

(*a*) Long wall (South Wales);

(*b*) Nottingham long wall or the Barry System.

And what extent of pillar and stall do you consider necessary for the same number? Seam, 5 feet 6 inches thick in each case.

3.—Give a description of the machinery and all appliances necessary in sinking two shafts to a depth of 400 yards. When would you stop sinking to put in walling? What would guide you on this point?

4.—Describe fully with dimensioned sketch the kind of tram you consider to be the best adapted for use in steam coal collieries. What kind of wheel would you adopt, and what do you consider the most effective method of lubrication?

Arithmetic.

1.—In a right-angled triangle the two sides of the right angle measure respectively 215 feet and 195 feet; find the hypotenuse.

2.—(*a*) Find the square root of 76,800 to three places of decimals.

(*b*) Express a link as the decimal of a yard.

3.—How many tons of coal are there in an estate of 637 acres, the seam of coal being 3 feet 10 inches thick, and the specific gravity being 1·27?

4.—What must be the depth of a cylindrical tank to hold 45,000 gallons of water, the diameter of the tank being 12 feet 6 inches, a gallon of water containing 277·274 cubic inches?

SECOND CLASS CERTIFICATES.

Mines Acts.

1.—State the requirements of the C.M.R. Acts as to the attendance of the winding engineman.

2.—State shortly the exceptions from provisions of the Acts as to shafts or outlets.

3.—What is the meaning in the Acts of a "Ventilating district"?

4.—What do the Acts provide as to the option of using the downcast shaft?

Arithmetic.

1.—A main return air-way, 11 feet 6 inches wide at the bottom, 9 feet wide at the top, and 7 feet 3 inches high under the collar. The velocity of the air current is 783.

What is the volume in cubic feet per minute?

What is the velocity of the same current where it passes through a length of the air-way which has been arched with a semi-circular arch to the following dimensions:—

Width between side walls, 7 feet.

Height to springing of arch, 5 feet.

* The writer does not vouch for the accuracy of the phraseology, but all figures and the substance of the questions are correct.

2.—The gross weight of 100 trams of coal is 133 tons 6 cwt. 2 qrs. Average tare of trams is 7 cwt. 2 qrs. What is the net weight of the coal ?

3.—The following are details of the earnings of a man and boy :
Coal, 47 tons 10 cwt. 2 qrs., at 1s. 10d. per ton.
Top, 17 yards, at 2s. 4d per yard.
Plus 57½ per cent on the standard in each case.
What are the total earnings ?

4.—A pump is 12 inches diameter, and 4 feet stroke. What quantity of water will it throw if working at 40 (double) strokes per minute ?

Coal Working.

1.—State the advantages or disadvantages of working double shift on the faces of an ordinary steam coal pit in South Wales.

2.—What provision would you make against underground fires ?

3.—What precautions are necessary to prevent fatal, serious, and small injuries to workmen ?

4.—Describe the proposed ambulance and rescue apparatus to be used at mines.

Practical Ventilation.

1.—Following a low barometer at a colliery in course of development gas exuded to such an extent as to fill the working places out to the main intake. To what causes would you attribute such an occurrence, and what steps would you take to restore adequate ventilation to the mine ?

2.—Suppose you were a fireman in a highly gaseous district in a steam coal colliery. Describe in detail what your duties would be from the time you entered the mine until you returned to the surface. The output from your district being 360 tons per day.

3.—Is it possible to have an explosion of coal dust without any fire-damp ? Explain fully under what circumstances, and say how you could render harmless the coal dust in a fiery mine.

4.—What is the most modern safety-lamp known to you ? Describe it.

5.—Under what circumstances is electrical power dangerous in a mine ? Where and how could the power be employed with safety ?

Suggestions for Candidates.

The above examinations are held annually about the third week in May, the time fixed for the 1912 Examination being :—For Second Class Certificates, May 21st and 22nd ; for First Class Certificates, May 23rd and 24th. The syllabus of subjects is as in previous examinations.

On careful perusal of the questions in the several subjects it will be noticed that certain of the papers are of considerably greater difficulty than others. The inference to be drawn is that greater importance attaches to proficiency in the more difficult subjects. Were the writer asked to place the subjects of the First Class Examination in the order of their importance, he would be inclined to tabulate as follows : (1) Machinery ; (2) Practical Working ; (3) Ventilation ; (4) Mines Act ; (5) Surveying ; (6) Arithmetic ; (7) Geology.

Assuming the above to be somewhat wide of the mark, the following would probably be a more correct arrangement :—

1.—Machinery, Practical Working, and Ventilation of equal and first importance.

2.—Mines Act, Surveying, and Arithmetic of equal importance, but less so than the first three.

3.—Geology, least important.

The following arrangement is suggested for the Second Class papers :—(1) Practical Working or Coal Working ; (2) Ventilation ; (3) Mines Act ; (4) Arithmetic.

Whatever the future may hold in store, unlike most other examination centres in South Wales it has never been the custom to require the candidate to qualify in *each subject separately*. The *aggregate* marks gained are entered to the credit of the candidate, and it is thus obvious that brilliancy and proficiency in certain subjects materially assist him to tide over subjects in which he is less confident. He should, however, beware of concentrating upon a subject of minor importance at the expense of another of relatively greater importance. While it is very desirable to become as proficient as humanly possible in each of the subjects of an examination, the candidate should endeavour to attain perfection most of all in what he believes are the "failing subjects" of the examination.

N.B.—The foregoing is the outcome of a suggestion that a few notes on the South Wales Mining Examination would be of interest to readers, and as a result the illustrations on Haulage are unavoidably held over until next issue.

(*To be Continued in next Issue*).

COAL MINING IN NEW ZEALAND

Contrary to previous expectations, the coal mining industry of New Zealand during the year 1910 showed considerable expansion and continued prosperity. As exhibited in the annual report, the total output was 2,197,362 tons, being an increase of 286,115 tons, which is double the increase in any previous year. The coal production has more than doubled during the last decade. This large increase is no doubt due to the continued prosperity prevailing in the other industrial pursuits during the decennial period, together with an improved export trade.

The comparative tonnage of the various classes of coal, &c., for the years 1909 and 1910 is summarised as follows :—

Class of Coal.	*Output for 1910.*	*Output for 1909.*	*Increase or Decrease for 1910.*
	Tons.	*Tons.*	*Tons.*
Bituminous and semi-bituminous ..	1,495,709	1,257,233	+ 238,476
Pitch coal	6,068	5,473	+ 595
Brown coal	594,995	559,509	+ 35,486
Lignite	100,590	89,032	+ 11,558
Totals	2,197,362	1,911,247	+ 286,115

As the result of the continued demand for coal, new collieries are being developed on the West Coast and in the Waikato. As soon as these mines are opened out they will no doubt add considerably to the mineral production.

There has been a gradual annual decrease in the quantity of coal imported during recent years. In 1908 287,808 tons were imported, valued at £274,605 ; 1909, 258,185 tons, valued at £253,081 ; and in 1910, 232,378 tons, valued at £230,765, being a reduction of approximately 57,000 tons in quantity, and £44.000 in value. On the other hand, considerable improvement took place in the coal export trade during the same period. In 1908, 100,502 tons were exported, valued at £85,846 ; in 1909, 201,685 tons, valued at £183,961 ; and in 1910, 277,011 tons, valued at £259,562, being an increase in two years of 176,509 tons in quantity, and £173,716 in value. These figures indicate that the first class quality of the bituminous coal commands a market not only in the Commonwealth, but also throughout the Southern Pacific. The opinion is expressed that the export of bituminous coal is capable of being enormously extended. The increased prosperity in the coal trade was practically participated in by every coal mine in the Dominion. There were 408 more men engaged in connection with coal mining in 1910 than there were three years ago.

State Coal Mines.—The output from the Point Elizabeth No. 1 and Seddonville collieries during 1910 amounted to 212,888 and 62,714 tons respectively, being in the aggregate a decline of 8,558 tons, as compared with the output for the previous year. This decline the report attributes to the approaching exhaustion of the older sections of these collieries ; but the extensive unworked coal area known as the Point Elizabeth No. 2 Mine has reached the output stage. The development works, consisting of incline tunnels and viaducts, are approaching completion. At the Seddonville Mine a considerable area of high class bituminous coal has been proved by diamond drilling in the Charming Creek section, and it is believed that a workable area will be developed adjoining the present mine. The briquette works in connection with the mine have not proved a success, owing to the high price of pitch and the heavy cost of manufacture.

COLLIERY ENGINEERING.

By CLANSMAN.

No. 9.—Linear and Angular Motion.

We give herewith summary in which is shown analogous relations in Linear and Angular Motion:—

Linear.		Angular.	
Time in seconds	$= t.$	Time in seconds	$= t.$
Displacement in feet	$= l.$	Angular displacement in radians	$= \theta$
Velocity in feet per second	$= v.$	Angular velocity in radians per second	$= \omega.$
Acceleration in feet per sec. per sec.	$= a.$	Angular acceleration in radians per sec. per sec.	$= a.$
Mass or inertia	$= m = \frac{w}{g}.$	Moment of Inertia $= I = mk^2$	$= \frac{w}{g} \times k^2.$
Force in lb.	$= F = ma = \frac{w}{g} \times a.$	Torque, in lb.-ft. units	$= T.$
Momentum	$= mv.$	Angular momentum	$= I\omega.$
Impulse in lb.	$= Ft.$	Angular Impulse in lb.	$= T \times t.$
Work in ft.-lb.	$= F \times l.$	Work of rotation	$= T \times \theta.$
Kinetic energy in ft.-lb.	$= \frac{mv^2}{2} = \frac{wv^2}{2g}.$	Kinetic energy of rotation	$= \frac{I\omega}{2}.$
Power in ft.-lb. per sec.	$= F \times v.$	Power	$= T\omega.$

Relations:—$l = \theta R$, where R = radius in feet. $v = \omega R$ and $a = a R$.

Uniform velocity	$l = vt.$	Uniform angular velocity:	$\theta = \omega t.$
With initial velocity	$= v_1.$	With initial angular velocity	$= \omega_1.$
And final velocity	$= v_2.$	And final angular velocity	$= \omega_2.$
Then uniform acceleration	$a = \frac{v_2 - v_1}{t}.$	Uniform angular acceleration	$a = \frac{\omega_2 - \omega_1}{t}.$
	$\therefore v_2 = v_1 + at.$		$\therefore \omega_2 = \omega_1 + at.$
	$l = v_1 t + \frac{1}{2}at^2.$		$\theta = \omega t + \frac{1}{2}at^2.$
	$v_2^2 = v^2 + 2al.$		$\omega_2^2 = \omega_1^2 + 2a\theta.$
Acceleration from rest	$a = \frac{v}{t}.$	Angular acceleration from rest	$a = \frac{\omega}{t}.$
	$\therefore v = at.$		$\therefore \omega = at.$
	$l = \frac{1}{2}at^2.$		$\theta = \frac{1}{2}at^2.$
	$v_1^2 = 2al.$		$\omega^2 = 2a\theta.$
Constant Force	$F = ma = \frac{w}{g} \times a.$	Torque: $T = Ia$	$= mk^2a.$
Impulse	$Ft = mv.$	Angular Impulse: $T \times t$	$= I\omega.$
Or Impulse causing change of momentum	$Ft = m(v_2 - v_1).$	Or Angular Impulse causing change of momentum: $T \times t$	$= I(\omega_2 - \omega_1).$
Work and Energy: $Fl = \frac{1}{2}mv^2$, or for change of velocity:	$Fl = \frac{1}{2}m(v_2^2 - v_1^2)$	Work and Energy: $T \times l$	$= \frac{1}{2}I\omega^2.$
		Or, for change of angular velocity: $T \times l$	$= \frac{1}{2}I(\omega_2^2 - \omega_1^2).$
Acceleration	$= \frac{\text{Force}}{\text{Mass}}.$	Angular acceleration	$= \frac{\text{Torque}}{\text{Moment of Inertia}}.$
Impulse	= change of momentum.	Angular impulse	= Change of ang'l'r m'mnt'm
Or since $F = \frac{m(v_2 - v_1)}{t}$		Or since $T = \frac{I(\omega_2 - \omega_1)}{t}.$	
Force	= rate of change of m'm'nt'm	Torque	= rate of change of moment of m'm'nt'm
Work	= change of kinetic energy.	Work	= change of kinetic energy.

The following examples may enable the reader to make himself acquainted with the foregoing analogies:—

Ex.—A shaft makes 80 revolutions per minute. Express this in radians per second.

Eighty revolutions per minute $= \frac{80}{60}$ revolutions per second. Each revolution $= 2\pi$ radians, and radians per second = radians in one revolution × number of revolutions per second. ∴ radians per second $= 2\pi \times \frac{80}{60} = 2 \times 3{\cdot}1416 \times \frac{8}{6} = 8{\cdot}377$.

The shaft carries a pulley 4 feet in diameter. Find the speed of its rim.

The speed $v = \pi DN = 3{\cdot}1416 \times 4 \times \frac{80}{60} = 16{\cdot}75$ feet per second.

Ex.—A man walks 20 feet in 4 seconds. Find his average speed.

Here $v = \frac{l}{t} = \frac{20}{4} = 5$ feet per second.

Ex.—A wheel turns through 480° in 3 seconds. Find its average angular speed.

Average angular speed in degrees $= \frac{480}{3} = 160°$ per second, and since $\frac{\theta}{\pi} = \frac{d}{180}$ where d = number of degrees and θ = number of radians.

$$\theta = \frac{\pi}{180} \times d = \frac{3{\cdot}1416}{180} \times 160 = 2{\cdot}792 \text{ radians per second.}$$

Ex.—A point moves in a straight line. At a certain instant its speed is 10 feet per second. After 8 seconds its speed is 50 feet per second. Find the average acceleration.

Here average acceleration $= \frac{\text{Change in velocity}}{\text{Time of change}} = \frac{50 - 10}{8}$

= 5 feet per sec. per sec.

It is usual to write 5 feet per second per second as 5′ per sec.^{2}

Ex.—A rotating body changes its angular velocity from 3 to 8 radians per second in 4 seconds. Find its average angular acceleration during this interval.

Here average angular acceleration

$= \frac{\text{Change in angular velocity}}{\text{Time of change}} = \frac{8 - 3}{4} = 1{\cdot}25$ radians per second^2.

Ex.—A rotating piece has at a certain instant a speed of 60 revolutions per minute, and an angular acceleration of 5 radians per second^2. Find the linear speed and the tangential acceleration at this instant of a point 2 feet from the axis of rotation.

Let R = distance of point from axis.

Linear speed of point $= 2\pi RN = 2 \times 3{\cdot}1416 \times 2 \times \frac{60}{60}$ = 12·56 feet per second.

Tangential acceleration = linear acceleration of point at instant taken.

$\therefore a$ = acceleration in radians $\times R = 5 \times 2 = 10$ feet per second^2.

Ex.—A train moving from rest with uniform acceleration takes 5 minutes to travel over the first mile. What speed has it acquired at the end of that time? How long does it take to travel over the second mile?

If we take v = velocity acquired, then the displacement $l = \frac{1}{2}vt$, and $v = \frac{2l}{t} = \frac{2 \times 5280}{5 \times 60} = 35{\cdot}2$ feet per second.

Let v_1 = velocity at end of second mile.

It begins the second mile with velocity $v = 35{\cdot}2$, and the acceleration continues. $a = \frac{v}{t} = \frac{35{\cdot}2}{5 \times 60}$.

$$\therefore v_1^2 = v^2 + 2al = 35{\cdot}2 \times 35{\cdot}2 + 2 \times \frac{35{\cdot}2}{5 \times 60} \times 5280$$

= 1239 + 1239 = 2478.

$\therefore v_1 = \sqrt{2478} = 49{\cdot}8$ nearly.

Average velocity during second mile

$= \frac{v + v_1}{2} = \frac{35{\cdot}2 + 49{\cdot}8}{2} = \frac{85}{2} = 42{\cdot}5$,

and $t = \frac{\text{Displacement}}{\text{Average velocity}} = \frac{5280}{42{\cdot}5} = 124{\cdot}3$ seconds.

Ex.—A pulley starting from rest and moving with uniform angular acceleration takes 8 seconds to make 6 turns. What is the angular velocity at the end of that time? How long does it take to make the next 6 turns?

The angular displacement $\theta = \frac{1}{2}\omega t = 6 \times 2\pi$.

$\therefore \omega = \frac{2\theta}{t} = \frac{2 \times 12\pi}{8} = 3 \times 3{\cdot}1416$.

$\therefore$ angular velocity $\omega = 9{\cdot}425$ radians.

Let ω_1 = angular velocity after 12 turns.

Pulley begins 7th turn with angular velocity = $\omega = 9{\cdot}425$, and the acceleration continues. $\alpha = \frac{\omega}{t} = \frac{9{\cdot}425}{8} = 1{\cdot}178$.

$\therefore \omega_1^2 = \omega^2 + 2\alpha\theta = 9{\cdot}425 \times 9{\cdot}425 + 2 \times 1{\cdot}178 \times 12\pi$ = 88·83 + 88·83 = 177·66; and $\omega_1 = \sqrt{177{\cdot}66} = 13{\cdot}37$ radians per second.

Average angular velocity during second 6 turns

$= \frac{\omega + \omega_1}{2} = \frac{9{\cdot}425 + 13{\cdot}37}{2} = 11{\cdot}4$,

and $t = \frac{\text{Angular displacement}}{\text{Average angular velocity}} = \frac{6 \times 2\pi}{11{\cdot}4} = 3{\cdot}32$ sec.

Ex.—A train moving at 20 miles per hour is brought to rest in 100 seconds, the retardation being uniform. Find the space passed over during this time.

Here the velocity $v = \frac{20 \times 5280}{60 \times 60} = 29{\cdot}3$ feet per second.

Let a = retardation, then $a = \frac{v}{t} = \frac{29{\cdot}3}{100} = {\cdot}293$,

and the space passed over, $l = \frac{1}{2}at^2 = \frac{1}{2} \times {\cdot}293 \times 100 \times 100$,

$\therefore l = 146{\cdot}6$ feet.

CANADIAN COAL PRODUCTION.

The quantity of coal produced in 1910 was 12,909,152 short tons, value $30,909,779; last year the amount was 11,291,553 tons, value $26,378,477. This represents a decline of 1,617,599 tons, and $4,531,302 respectively. These figures are from the preliminary report of the Department of Mines, and for the falling off the long continued strike in the coal mines of southern Alberta and eastern British Columbia is held responsible. There was an increase of 562,978 tons in Nova Scotia, and of 23,097 tons in Saskatchewan. In Alberta the decrease was returned at 1,396,412 tons, or 48 per cent., and in British Columbia 794,243 tons, or 24 per cent.

The production by provinces was approximately as follows, the figures for 1909 and 1910 being also given:—

Province.	1909.		1910.		1911.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$
Nova Scotia	5,652,089	11,354,643	6,431 142	12,919,705	6,994,120	14,050,687
British Columbia .	2,606,127	8,144,147	3 130,745	10,408,580	2,536,502	7,926,569
Alberta.....	1,994,741	4,838,109	2,894,469	7,065,736	1,498 057	3,933,958
Saskatchewan	192,125	296,339	181,156	293,923	204,253	342,921
New Brunswick ..	49,029	98,496	55,455	110,910	55 781	111,562
Yukon Territory..	7,364	49,502	16,185	110,925	2 840	12,780
Totals	10,501,475	24,781,236	12,909,152	30,909,779	11,291,553	26,378,477

TEMPERATURE OF ICE.—Is ice any colder in winter than in summer? Most people suppose not. They understand that ice is ice, and cannot be any colder or warmer. If a thermometer is buried in ice in summer it will indicate thirty-two degrees. If you throw a piece of ice into boiling water and leave it there till it is almost gone, what is left will still be at thirty-two degrees. Ice can never be gotten above that temperature. But while ice can never be warmed above thirty-two degrees, it will go as much below that as the weather does. An iceman delivering ice one zero day in January was asked whether his ice was any colder than in July. He thought not. But as a matter of fact a piece of summer ice, if he had had it, would have been something of a foot-warmer for him, as it would have been thirty degrees warmer than the air of the bottom of his wagon. Mixing salt with ice makes it much cooler. The ice in an ice cream freezer goes down to about zero. This is why the point zero on our common thermometers was fixed where it is. It was supposed to be the lowest point that could be reached by artificial means. Since then we have reached about 383 degrees below zero by chemical processes. Ice will cool down with everything else, on a cold night, to zero or below. What should prevent it? On a day when it is just freezing, a block of iron and a block of ice outdoors will stand at thirty-two degrees. If the weather grows warmer the iron will warm up with the weather, but the ice will stay at thirty-two degrees and melt away. But if the weather grows colder the iron and the ice will cool off too, and one just as much as the other. As the ice grows colder it gets harder and more brittle. There can be no "hickory bend" on the skating pond on a zero day, for ice is then too brittle. Slivers of ice dipped in liquid air become so hard that they will cut glass. Water thrown on ice in the Arctic regions will shiver it like pouring boiling water upon cold glass. This is because the ice is so much colder than the water.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications.

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Will some reader please solve the following problem:—

The winding space in a shaft is 8 feet × 6 feet. The door-heads are 7½ feet high. Find the length of the longest "stick" that could be taken into the mine.

Yours, &c.,

A PIT-BOTTOMER.

To the Editor of The Science and Art of Mining.

SIR,—Will any of your readers describe by sketch what is meant by working coal on the "face," "on end," and "half on?"

Thanking you in anticipation.

Yours, &c.,

WELSH TYRO.

To the Editor of The Science and Art of Mining.

SIR,—Will you kindly allow me space for the following questions in your paper?—

1.—Suppose there was a large fall of roof in the main return air-way; what effect would it have on the water-gauge?

2.—Can any reader sketch and describe clearly some contrivance for "greasing" a haulage rope other than using the ordinary bucket and brush?

Yours, &c.,

J. W. T.

Laws of Falling Bodies.

To the Editor of The Science and Art of Mining.

SIR,—In reply to JAMES HISSETT in No. 18, Vol. 20, I could understand how he arrived at $16s = 805t - 402{\cdot}5$. I wanted an explanation of

$$\therefore \frac{s}{t} = \frac{402{\cdot}5}{16}.$$

This is where the solution fails. The transposing is incorrect—

$16s = 805t - 402{\cdot}5$. $\therefore \frac{s}{t} = \frac{805}{16} - \frac{402{\cdot}5}{16t}$.

$\therefore s = 50{\cdot}3125t - 25{\cdot}15625$.

$s = \frac{1}{2}gt^2 = 16{\cdot}1t^2$. $\therefore 50{\cdot}3125t - 25{\cdot}15625 = 16{\cdot}1t^2$.

$$\therefore \frac{t^2}{t} = \frac{50{\cdot}3125}{16{\cdot}1} - \frac{25{\cdot}15625}{16{\cdot}1t} = 3{\cdot}125 - \frac{1{\cdot}5625}{t}.$$

$$t = 3{\cdot}125 - \frac{1{\cdot}5625}{t}.$$

Without bringing it any further 2·5 or ·625 will satisfy the equation.

Yours, &c.,

T. W.

Ventilation.

To the Editor of The Science and Art of Mining.

SIR,—Being a constant reader of your valuable Mining Journal, I have come across the following in Vol. XXII., No. 17.

What would happen if the doors on top of the upcast were opened? Would the fan stop, slow down, or increase in speed?

Well, they all say that it would increase in speed; and ENGINEERING STUDENT says, by aid of a formula extracted from a book by H. W. G. Halbaum, that it would increase in speed if the underground separation doors were opened.

Will you kindly insert the following for a little discussion. I say the fan would slow down and deal with a larger volume of air, because the friction or drag of the mine would be cut off. I know of an instance some time ago where the mine separation doors were opened, and the fan slowed down, and had a bumping sound as if dealing with a heavier load. I am willing to fall into my mistake if there is any, but it seems the general thought of modern mining engineers that the fan will slow down.

Yours, &c.,

A. DAVIES.

To the Editor of The Science and Art of Mining.

SIR,—What would happen to the fan if the doors at the top of the upcast were suddenly opened? Would the fan stop, slow down, or increase in speed?

In answering this question in your issue of March 30th your contributor TYKE suggests that the fan would speed up. May I suggest that he try the experiment for himself and see. I think he will find—by whatever process of reasoning he arrives at the cause—that the fan will really slow; that is, if it be driven by an ungoverned engine. Whether or not the fan would really stop depends in some measure on the kind of engine driving it, and the rate at which the engine runs. Because if the engine were a single, slow-running one, conveying its force through gear or belting to the fan, with just sufficient motion on to carry itself over its centres when running normally, it is more than likely that it would stop when the extra volume of air entered the fan. I was amused at the curiously fallaceous arguments that your contributor adduced to establish his contention. For example, he says, as a result of opening upcast doors a large volume would rush in to the fan drift from the outside atmosphere, *which air would certainly offer less resistance to the fan than the air from the mine.* The last part of that remark is incorrect. The air entering from the atmosphere is certainly denser than the air originally coming from the mine, therefore, what more natural than that the fan should not pass so easily through it? He admits that the W.G. has fallen in the fan drift. This is itself an admission that the air entering the fan is now denser. He also talks of the opening of the doors *taking the resistance of the mine off the fan.* That also is a fallacy. Air will be entering the fan not only from the atmosphere, but from the mine, so long as both ways to the fan are left open, because air cannot enter the fan drift through the upcast doors without meeting *some* resistance, and just the same measure of resistance shall be offered by the mine to the passage of such air as shall reach the fan through it. Hence, what has really been done by the opening of the doors at the upcast shaft is equal to an increase of the equivalent orifice of the mine—reckoning the entry through the doors as a part of the mine—because we would have the fan running at the same rate and producing the same increased quantity of air—if some magician had come along and increased the size of existing air-ways instantaneously, just enough to give the same easy access of air to the fan through the mine itself with upcast doors shut, as it now has through the mine and the open upcast doors combined. In adducing the pump as an illustration your contributor misses the point entirely, or rather applies it in an inverted way. To make any approach to a truthful comparison he should have had the pump going first on air, and then given it a little water, and finally solid water; watching the effects the while. This, in some degree, would have compared with a fan pumping air somewhat attenuated through a mine, and then being fed and filled with air somewhat less attenuated through a combined mine and doors. Or, he might just imagine a fan set to work driven by an ungoverned engine, exhausting air out of a completely closed chamber, and measure how much it exhausts after it has run a minute or so. He could then commence opening an aperture into the chamber. After having opened it a bit he could test whether the fan was now passing more air than it did when the chamber was closed, and whether it was running faster as a result? If he gradually kept widening the aperture, and watching the effect, I can imagine his eyes gradually widening with wonder at the result, because, while the flow of air gradually increased, the speed of the fan would be gradually reduced.

Yours, &c.,

Larkhall, WM. M. KILPATRICK.

A Mis-statement.

To the Editor of The Science and Art of Mining.

SIR,—I venture to correct a mis-statement which occurs in your last issue, p. 415, in connection with the composition of the air. In speaking of oxygen and its proportion in the atmosphere normally, your contributor states that "To produce an atmosphere fit to breathe, *no free oxygen can be allowed.*" (The italics are mine).

May I point out that *all* the oxygen in the atmosphere is in the free condition. None of it is combined. Air is a *mixture* of gases, not a compound. If there is no free oxygen in an atmosphere human life cannot exist.

Yours, &c., T. H. BYROM.

[NOTE.—"TYKE" proposes to deal with the above questions by "A Pit-Bottomer," "Welsh Tyro," and "J. W. T." as time and space permit. He also proposes to deal with the letters from Messrs. A. Davis and Wm. M. Kilpatrick.]

SURVEYING.

By COLLIERY SURVEYOR.

Y and Dumpy Levels

The following remarks relating to Y levels are made by Mr. W. F. Stanley in his excellent work on *Surveying and Levelling Instruments* :—

"The oldest form of surveyor's level is that known as the Y level, so called from the telescope being supported in Y-formed bearings. It was invented by Jonathan Sisson in the last century. It is very little used nowadays, especially in Great Britain, but on the Continent and in America it appears to still hold a place. In the eyes of the *optician* it is still the most perfect level, possessing all the instrumental refinements of adjustment. The reason for its partial abandonment is owing to the number of loose parts, the loss of any of which is a serious matter when work is being done far away from civilisation and facilities for replacement. Other objections are that Y's and collars wear by constant friction in being carried about, and tend to form facets ; the collars also become corroded, and they collect flying dust, which gives rise to imperfection. Also, that the cross bubble which is always attached to the *dumpy* level saves a lot of time over swinging the telescope backwards and forwards. Also in the dumpy level the vertical and horizontal webs of the diaphragm are fixed, and cannot be disturbed by rotation of the telescope when once fixed up, and this is specially useful to enable the observer to determine whether the staff is held vertical or not, which is otherwise a great difficulty with the ordinary form of Y level reading."

Figure 111 shows a good form of dumpy level. It consists of a telescope *T* which carries a ray shade at the object glass end to avoid the direct rays of the sun when low on the horizon. The eye-piece *EP* is adjustable inwards or outwards, either by rotating or by sliding. *BT* is the bubble tube, and *CB* is a cross bubble tube at rt. ∠s to *BT*. *H* is a hinge joint, and *LN* are locking nuts which serve to support and also to adjust the bubble tube parallel to the telescope axis. *WD* indicates the position of the webbed diaphragm, which moves in a slide piece, and is adjustable by means of the capstan headed screws *CS*. *S* and *S* are straps passing round and soldered to the telescope, and afford support for the bubble tube, as well as support for the whole upon the limb *L*. *SS* is the socket screw, around which the instrument rotates. *FS* is the focussing screw, by means of which the inner sliding tube with its object glass can be moved as required to give a clear vision. *LS* are the mill-headed screws used for levelling the telescope, and *A* is the point of attachment (by means of an internal thread) to the tripod.

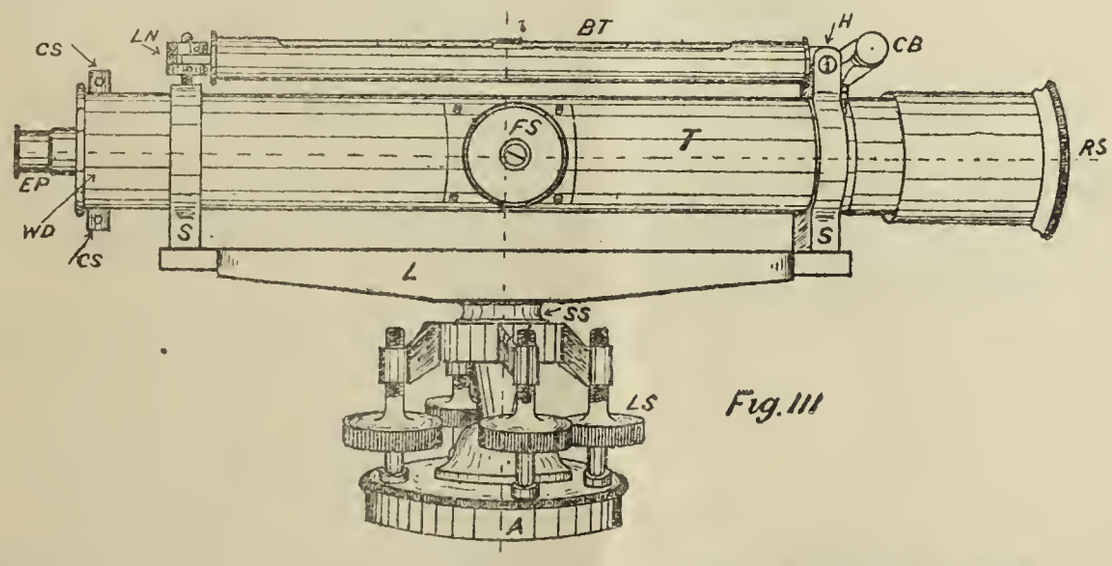

Fig. 111

Examples to be Worked Out.

Readers working out the appended questions and who desire a test o their ability, should submit their answers to COLLIERY SURVEYOR, care of *he Science and Art of Mining* Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means answers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonies and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to COLLIERY SURVEYOR at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the regular series of articles.

1.—*Draw a neat sketch, with letters of reference, of the Dumpy level, and, if you can, show in cross section the arrangement of the webbed stop in the diaphragm.*

2.—*State the causes which have operated to cause the displacement of the Y level by the Dumpy ; in other words, compare the Y and Dumpy levels.*

3.—*If the line of collimation in a Dumpy level was out of adjustment, how could you find two level points ?*

4.—*Find the quantity of earth required for an embankment whose uniform depth is 20 feet, surface width 33 feet, length 1 chain, and slopes 1½ to 1.*

PEAT POWER AS LOCOMOTIVE FUEL.

The problem of finding a suitable form for peat as a practical and economic fuel for locomotives continues to engross the attention both of railway authorities and peat experts. More especially in Sweden the problem is to the fore, but no satisfactory solution appears to have been arrived at as yet. The general director of the State Railway is much interested in the matter, and recently submitted drawings of locomotives to a very well-known peat expert for him to design a suitable fire-box, which, however, has not yet been done. It would seem that, although peat powder may prove a desirable fuel for stationary boilers, the difficulties offered by the locomotive have not yet been disposed of.

ADEQUATE BRAKES FOR WINDING ENGINES.

By MYLES BROWN.

"*A.B.S. Brake*" (*Patent*).—The A.B.S. Patent Brake was invented jointly by the manager and engineer of an important colliery, and in the first instance was fitted to a pair of 24 inches × 48 inches winding engines. The brake is now in daily operation, and giving excellent results.

The elevation (*Figure 3*) shows the application of the A.B.S. Brake to a winding engine.

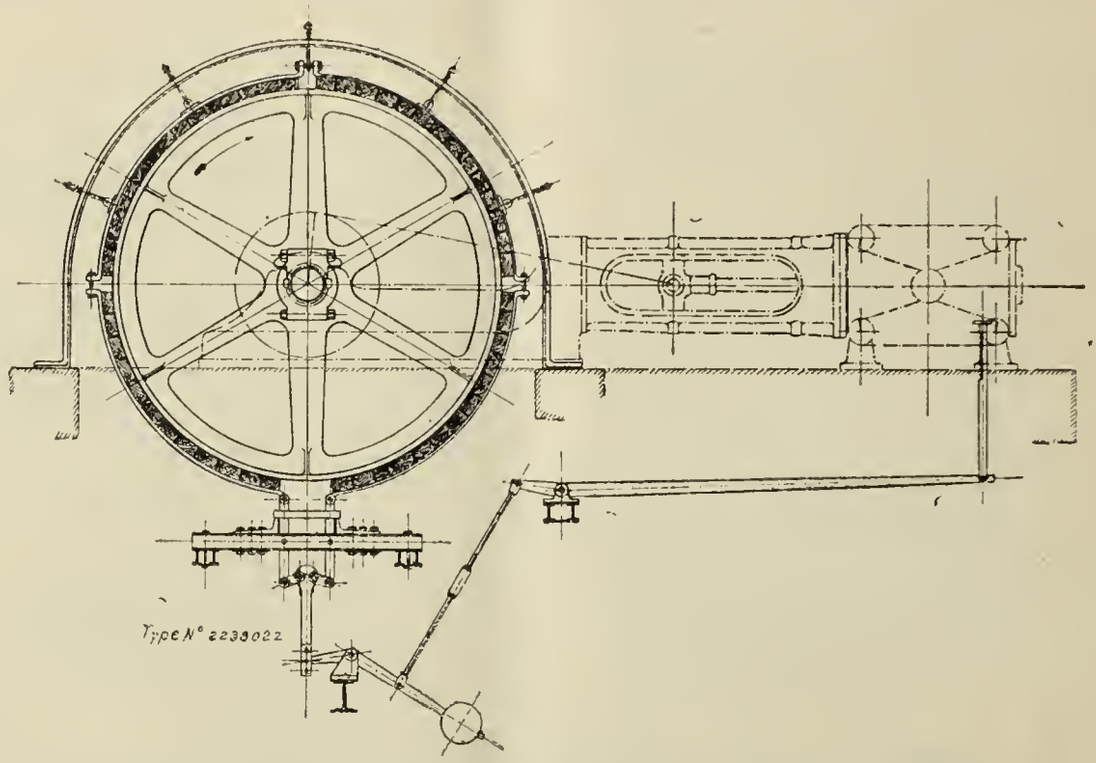

Figure 3.—Elevation showing Application of the "A.B.S." Brake to a Winding Engine.

Special Features of the Brake.—(1) The sole makers (Messrs. Andrew Barclay, Sons, and Co., Ltd., Caledonia Works, Kilmarnock) specify the brake to effectively fulfil the requirements of the new Mines Act. The Act requires that "where the apparatus used for lowering or raising persons is worked by mechanical power, there shall be provided one or more brakes of sufficient power by themselves to hold the cage when loaded at any point in the shaft."

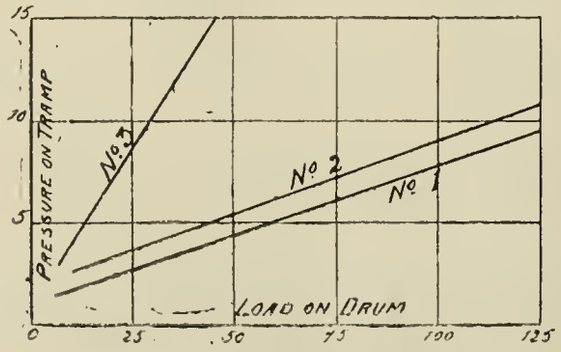

Figure 4.

(2) The power of the A.B.S. Brake and its effectiveness for both directions of running is accomplished by a specially-designed brake with toggle joint, which is clearly shown in the illustrations given. The power of the A.B.S. Brake compared with the ordinary strap brake is shown in the accompanying diagram (*Figure 4*):—

The diagram is a record of experiments made with a brake arranged as an "A.B.S." Brake, and as an ordinary strap brake, *the same strap and brake path being used in each case.*

Line No. 1 is the record for the "A.B.S." Brake; line No. 2 the record for the ordinary strap brake with the drum running in the most favourable direction; and line No. 3 the record for the ordinary strap brake with the drum running in the least favourable direction. The experiments were made by hanging different loads at the circumference of a drum, and recording the least pressure on the brake tramp which was necessary to prevent the load moving. The *brake mechanism* used in both cases was identical. It will be observed that in the case of the A.B.S. Brake the weight supported at the drum circumference for any given load on the tramp is greater than that supported when the ordinary strap brake is used, even with the drum revolving in the best direction, and very much greater when the drum is revolving in the least favourable direction.

(3) The A.B.S. Brake exercises no distorting force on the drum, and as there is a large brake surface the wear and tear and the necessity for frequent adjustment are consequently reduced.

(4) The A.B.S. Brake, although very powerful, is remarkably easy to control; very little effort is required to put it on.

(5) The exertion of one man is capable of holding any load, at any point in the shaft, or lower the loaded cage into the pit bottom without the use of steam against the engines. It is stated that at the colliery where this brake was first applied the loaded cage could be made to creep in the shaft, controlled by the brake entirely, without any assistance from the engine.

Application or Working of the A.B.S. Brake.—The brake is applied by the usual tramp action, which causes a pull on the vertical rod which straightens out the toggle joint, thus tightening the strap.

The brake is particularly easy of application; indeed, it could well be applied at full power by the pressure of the fingers. This is due to the fact that when the strap is in contact with the brake path the drag of the brake path on the strap draws it up tighter, consequently, the effort applied by the engineman only takes up the slack, and in this way full advantage of the coil friction is obtained. The brake can be brought into action very gently, being put on against the resistance of springs hung from a steel arch, or it can, when necessary, be instantly

applied at full power. In the same way the brake may be released in the most gradual or sudden manner.

Perfect contact is secured between the brake path and the brake strap by making the strap in four separate segments, and in this way also a great range of adjustment is obtained. It is possessed of great holding power in both directions, and certainly has a manifest advantage over the ordinary post brake, as its enormous braking power is not dependent upon any large expenditure of physical force by the engineman.

The A.B.S. Brake can be adapted to existing engines as readily as it can be fitted to new engines. It is also suitable for steam as well as foot or hand application, though a steam brake of this design would only be necessary with engines of the largest size.

DISCIPLINE IN MINES.

In considering the matter of mine discipline the great desideratum of moral courage should not be overlooked. The lack of this quality in officials no doubt often leads to disaster, and while the results may be trifling if the cases are taken separately, the cumulative effect is nevertheless very great.

The mine inspector or mine official who lacks the courage to reprimand, or, if need be, prosecute the workman whom he finds flagrantly violating the law, is falling short of doing his duty as an official, whose thought and effort should be given to remedying or removing conditions that may be a menace to safety. The annual report of the Pennsylvania Mines Department says the moral courage that will enable a man to adhere strictly to the line of duty at all times, even in the face of the opposition, interference, or intimidation of officials or employés, is absolutely necessary to the successful carrying out of the laws and rules of safety.

There is no place in which discipline is more necessary than in the coal mines where aliens who cannot speak English are employed in great numbers. Most of them have come from European countries where they were more or less under military restrictions, and, we are told, they mistake the liberty they enjoy in America for licence. Many of them are unfamiliar with mining practices, and the discipline under which they are obliged to work makes them restless and often resistant; they resist it whether it be imposed by the owners or by their own organisations. These people, however, need discipline, not only for their own protection, but for the protection of their fellow-workmen, and while the discipline may be kind, it must be firm; they must be held to strict obedience. A deplorable percentage of accidents can be attributed to the lack of discipline that makes it possible for the mine workers to become careless and negligent to an extent that they are a menace, not only to their own lives, but to the lives of their fellow-workmen.

A mine may be a model institution as far as equipment and safety appliances go, but without the enforcement of rigid discipline among the employés it is still a place of great danger. Violations of the laws and of the rules of the mine should invariably be punished, and the Director of the Mines Department says the official who fails to exact punishment should be counted as guilty as the person who committed the violation. In addition to the immediate calamitous results that may follow a laxity in demanding compliance with the laws and rules, there is bred in the minds of the workmen a disregard for all discipline and control.

The question resolves itself practically into the matter of the official compelling the employé to protect himself, but just to what extent the official should interfere and demand compliance with the law is a problem difficult of solution. Too great exactitude is resented by the worker, and may result in his refusing to continue at work, while, on the other hand, leniency means constant liability to disaster and a weakening of authority.

There is undoubtedly at all times room for discipline in connection with the working of coal mines, and in America the problem is all the more acute by reason of the "mingling of the nations." From particulars collected by the Pennsylvania Mines Department a table has been prepared showing the nationality of the anthracite mine workers, and although those classified as American include all born in the country even though their parents are foreign and unacquainted with the English language, it must be confessed that the percentage of Americans working inside the mines is not a high one. The foreigner predominates, as will be seen upon reference to the table appended:—

Nationality.	*Below.*	*On Surface.*	*Totals.*
American	25,370	20,322	45,692
English	4,144	1,346	5,490
Welsh	5,272	960	6,232
Scotch	745	232	977
Irish	7,861	3,184	11,045
German	3,516	2,006	5,522
Slavonian	8,315	4,093	12,408
Italian	7,490	3,828	11,318
Polish	24,847	4,376	29,223
Hungarian	3,065	1,878	4,943
Austrian	3,629	1,245	4,874
Swedish	153	65	218
Russian	15,720	2,140	17,860
Belgian	——	10	10
Bohemian	55	9	64
French	98	60	158
Canadian	16	8	24
Lithuanian	13,963	1,200	15,163
Greek	804	420	1,224
Tyrolean	761	62	823
Danish	15	7	22
Syrian	18	90	108
Montenegrin	35	9	44
Horwat	66	14	80
	125,958	47,564	173,522

ILLINOIS COAL STATISTICS.

In the 30th annual coal report the statistics relating to labour and output at the mines in the State of Illinois are set forth with considerable detail to the year ending June 30th, 1911. The impression given is that the small mine is being eliminated, seeing that whereas the number of mines operating in 1906 was 1,018, the figure was reduced to 845 in 1911, representing the closing down of 17 per cent. of the collieries. Notwithstanding this, there has been an increase of 15,127, or 24 per cent., in the number of employés, and it requires but a simple calculation to ascertain that whereas in 1906 the labour force averaged 61 for each colliery, last year the average was 91. In the matter of coal output there has been a rise of 11,847,518 tons, last year's total of 50,165,099 tons representing a percentage increase of 31 on the six years' working. These figures are of interest as showing the modern tendency to operate on a larger scale, an experience with which the colliery people in Great Britain are themselves not unfamiliar, and a table of totals and averages for the six years may at the present time be specially appropriate as follows:—

Year.	Mines.	Men.	Tons.	Machines.	Coal got by Machines.	Killed.	Deaths per 1,000.	Tons coal per death.	Output per person.	% Machine got coal.
1906	1,018	62,283	38,317,581	962	9,563,230	155	2·5	247,210	615	25
1907	933	66,714	47,798,621	1,105	14,490,454	165	2·5	289,689	716	33
1908	922	70,841	49,272,452	1,160	15,210,423	183	2·6	269,248	695	30
1909	886	72,733	49,163,710	1,246	16,407,692	213	2·9	230,816	676	33
1910	881	74,634	48,717,853	1,289	18,176,254	406	5·4	119,997	653	37
1911	845	77,410	50,165,099	1,430	19,998,259	157	2·0	319,523	648	39

Coal in Canada.

It has been estimated by the Canadian Geological Department that the total coal content of the three Provinces of Manitoba, Saskatchewan, and Alberta, together with Eastern British Columbia, is 143,490,000,000 tons, covering an approximate area of 22,506 square miles, says *Western Canada Progress*. Of this quantity about 400,000,000 tons are anthracite, 860,000,000 tons range from anthracite to semi-anthracite, 43,070,000,000 tons from semi-anthracite to bituminous, and the balance is of a poorer quality of coal or lignite.

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The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, APRIL 27, 1912.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

No. 6.—Flame Tests for Fire-damp—(continued).

In mine air containing less than 2 per cent. of fire-damp the safety-lamp in its ordinary working condition and without special fittings, is not sufficiently sensitive to give to the average fireman, examiner, or deputy, definite and *unmistakable* indications of the small amount of gas present.

The gas cap obtained in such circumstances is extremely delicate in outline, and is not easily distinguished from the natural "fuel cap" produced by the oil flame when reduced, particularly if the mine temperature is high.

At the best, the effects produced are small, and considerable training in the detection of minute differences in the structure of caps in all kinds of conditions is necessary, before an official can accept with confidence any observation as an indication of a definite percentage of gas.

For practical purposes it is not satisfactory that the estimation of small percentages of gas should have to depend on such elusive effects. In order to increase the range of certainty and reliability obtainable with a safety-lamp, various attempts have been made to devise methods by means of which the cap can be made more apparent and of an increased size. Some of these methods are given below.

The Cunynghame-Cadman Device.—This device has been worked out by Sir Henry Cunynghame, of the Home Office, and Dr. Cadman, Professor of Mining at the University of Birmingham. Its simplicity in action and the soundness of the principle on which it is based recommend its application.

As previously explained, an envelope of burning gas exists around all flames exposed to an atmosphere containing fire-damp, the size of which increases with the size of the flame. In ordinary circumstances this is invisible owing to the activity of the white light. It is obvious, therefore, that if the large cap formed on the full flame could be made visible the value of the safety-lamp as a gas detector would be increased.

Certain chemical salts, such as carbonate of soda, and cuprous chloride, when inserted in a flame, react upon it in such a way as to give it a distinctive colour—the former salt giving a yellow colour; the latter, green. Hence, by suitably introducing either of the above chemical substances to the flame of a safety-lamp burning in a gas mixture, the fire-damp cap takes on the colour due to the salt, and becomes visible, even when the oil flame is full sized.

The "C.C." device is an easy means whereby this effect can be produced in practice. It consists of a strip of thin asbestos sheeting steeped in a suitable solution of either of the above chemical salts. The strip of impregnated asbestos is held in a horizontal position by a suitable holder. This can be operated from the outside of the lamp by a wire passing through the oil vessel. *Figure 2* shows an arrangement of the device in which the asbestos strip and the operating wire can be seen.

When a test is to be made, the asbestos strip is brought forward by means of the wire and inserted into the *full flame*, about one-quarter of an inch above the top of the wick. In the absence of gas no increase of flame is produced. If gas is present the fire-damp envelope is coloured according to the chemical used, its size and distinctness varying with the percentage. In 3 per cent. of gas the cap is very striking, and may be seen a considerable distance away. In 1 per cent. (on a full flame) a distinct coloured cap nearly half an inch high is produced.

A certain amount of experience in manipulation of the device is necessary to obtain the best results. With this, as with all flame tests, the conditions under which the test is made must be standardised.

The asbestos strips are renewable, and any existing lamp can be adapted to the device for a small sum.

The Briggs Loop.—This device has recently been introduced by Mr. Henry Briggs, of the Heriot-Watt College, Edinburgh.

Its object is to make visible a larger gas envelope than can be obtained by the ordinary method of testing. This is attained by suitably introducing to the full flame a loop of No. 22 S.W.G. copper wire. The effect of the insertion of the loop is to abstract

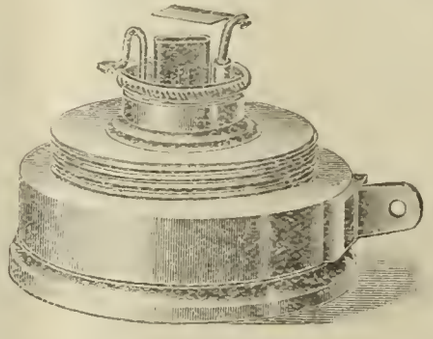


Figure 2.

The Cunynghame-Cadman Device.

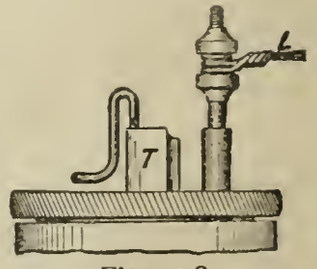


Figure 3.

The Briggs Loop—withdrawn from the flame.

heat from the flame in sufficient quantity to destroy the incandescence of the minute carbon particles which give rise to the white light, thereby rendering the test flame practically non-luminous. As the introduction of the loop does not greatly reduce the size of the oil flame a large test flame is produced, which, it is claimed, can be easily standardised by adjusting the position of the loop.

The loop is one-eighth of an inch broad, and in length is equal to the breadth of the wick tube. It is supported on a vertical brass stalk which extends through the oil vessel of the lamp. This can be operated so as to move the loop horizontally in or out of the flame as required. A certain amount of vertical movement can be obtained on the stalk. The upper end of the vertical stalk with the loop *L* attached is illustrated in *Figure 3*. *Figure 4* shows the loop, fitted to a Davis Al fireman's lamp, in the position for testing.

The testing flame is produced without drawing down the wick, hence, there is no risk of losing the light. The device can be fitted to any type of lamp, and as it is not delicately constructed promises to be a useful aid to gas testing.

The loop accentuates the "fuel cap" with all common safety-lamp oils. It is necessary, therefore, to become familiar with

the appearance of the test flame in pure air before and after the insertion of the loop. With a reasonable amount of training it is claimed that a person can detect well below ½ per cent. of gas.

The Clowes Hydrogen-Oil Safety-Lamp.—This is essentially an oil lamp, adapted to take hydrogen from a small cylinder attached to its side for testing purposes.

As a rule the oil lamp used is of the improved Gray type, admitting air below the flame from three or four vertical tubes. The oil vessel is provided with a special fitting to which the small steel cylinder can be rapidly attached. From this fitting a fine copper tube extends through the oil vessel, and terminates near the oil wick. The cylinder is provided with a valve to regulate the supply of hydrogen to the jet tube. It is attached to the lamp only when testing for small percentages of gas, during which process it serves as a convenient handle. At other times the cylinder may be carried in the pocket. See *Figure 5.* The oil flame is used for ordinary purposes of illumination, and for testing in air containing 2½ per cent. or more, the reactions being the same as in any other lamp.

If no distinct cap is seen on the reduced oil flame, the hydrogen cylinder is taken from the pocket and attached to the special fittings. The valve is slowly opened and hydrogen gradually admitted to the jet, where it ignites at the oil flame. The oil flame is now extinguished by drawing down the wick, and the gas tests made on the small hydrogen jet.

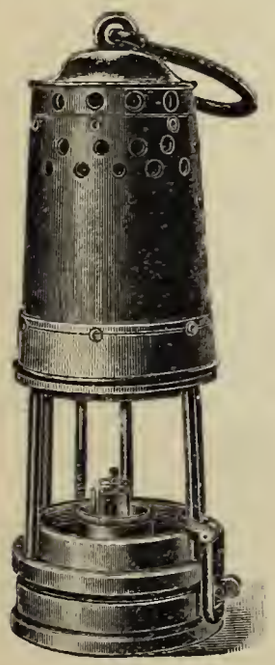


Figure 4.
The Briggs Loop in test position.

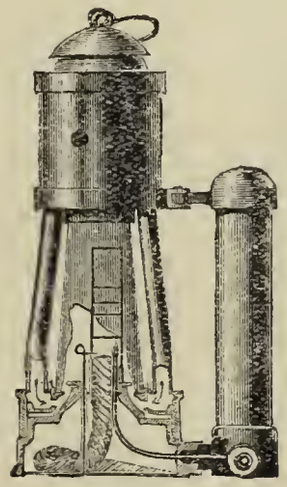


Figure 5.
The Clowes Hydrogen-Oil Safety Lamp.

Like all other test flames, the hydrogen flame must be standardised before definite results can be obtained. The standard height used is 0·4 inch. As the flame is naturally non-luminous no further adjustment is necessary. The caps obtained on such a test flame are as follows :—

Percentage of Gas.	*Height of Cap in Inches.*	*Remarks.*
·25	0·7	Cap pale and hazy in outline.
·50	0·7	Cap more definite in outline.
1·00	0·9	Increased definition and density of colour.
2·00	1·2	Ditto, ditto.
3·00	2·1	Ditto, ditto.

When the hydrogen test is completed the oil wick is pushed up and kindled at the hydrogen jet. The hydrogen valve is now gradually closed and the cylinder detached from the lamp.

A ladder scale is provided with the lamp to denote the gas percentages. The bottom wire of the ladder marks the height of the standard flame. The tip of the copper jet tube must always be precisely 0·4 inch below the standard mark. The other register wires on the scale indicate the percentages given in the above scale.

For fine readings, such as are required by the Coal Mines Act in intake air-ways, in return air-ways, in open light pits, and in any circumstances in which there is less than 2 per cent. of gas, this appliance, in the hands of an experienced person, should prove useful.

The Stokes Alcohol Lamp.—This is a gas-testing lamp devised by the late Mr. A. H. Stokes, H.M. Inspector of Mines, and is a modified Gray safety-lamp to which a small vessel containing absolute alcohol can be attached for fine testing. The safety-lamp itself is used in the ordinary way for illumination, and for testing for gas in air containing 2½ per cent. or more. If no distinct cap is shown on the oil flame, the alcohol vessel is attached to the oil vessel. The former has a long wick which, when in position for testing, extends through the oil vessel, and terminates near the oil wick, at which it can be ignited. After the alcohol flame has been properly established the oil flame is extinguished by drawing down the wick by means of the pricker. Further tests are now made on the non-luminous alcohol flame.

The standard flame is half an inch high, and gives the following caps :—

Percentage of Gas.	*Height of Cap in Inches.*	*Remarks.*
0·5	0·60	Very pale. Not clearly seen.
1·0	1·00	Pale blue. Clearly seen.
1·5	1·44	Pale blue. Clearly defined.
2·0	1·68	Clear blue. Cone.
2·5	2·00	Distinctly defined cap.

The alcohol tester is not intended to be used until the oil flame has failed to detect gas. As it is small and can be carried in the waistcoat pocket, the appliance should be a useful aid to an official having occasionally to make fine observations.

The Garforth Gas Detector.—This detector is specially useful for shot-firers in their examinations previous to the firing of shots, and was highly commended by the late Royal Commission on Mines.

The principle of this device consists of collecting a sample of the atmosphere to be tested by means of an indiarubber ball, and passing it through a tube into the oil vessel, to the oil flame, at which it is ignited. In the report of the Royal Commission Mr. Garforth describes the arrangement as follows :—

"The detachable rubber ball is inserted into a break in the roof, and after the air contained in it has been expelled by pressure of the hand it is allowed to expand, whereupon it becomes filled with a sample of the suspected atmosphere. The contents of the ball are then introduced on to the flame of the lamp through a safety gauze-protected pipe, which the brass nozzle of the ball exactly fits. If fire-damp be present it is shown by an elongation of the lamp flame, and by a blue cap burning at the top of the gauze-pipe, which latter is fitted with a small spring valve raised when desired by the serrated brass nozzle of the ball. . . . As the method of detecting fire-damp by means of the indiarubber ball has been in daily use for the past twenty-four years, it is interesting to note that the opinion of more than one hundred colliery officials is :—

(*a*) That the ball enables a deputy to discover fire-damp which cannot be found by the ordinary tin shield lamp. . .

(*b*) That it is safer to bring a suspected atmosphere to the lamp by means of the ball than to introduce a lamp into gas. . . . . ."

Other claims are made for this device, which undoubtedly is a useful appliance.

Numerous other special gas detectors are made, but probably sufficient have been mentioned to indicate the general nature of the methods adopted to detect fire-damp without having recourse to gas analysis.

PRIZE COMPETITION.

"Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has been generally distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, May 7th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 20, Vol. XXII., but in No. 21, Vol. XXII.]

PREPARATORY.

Q. 1. ROPE BORING.—*Describe simply the method of putting down a deep bore-hole by the American system of rope boring.*

Q. 2. EXPLOSIVES.—*Briefly and concisely, under what circumstances do you consider a high explosive preferable to ordinary gunpowder?*

Q. 3. SUPERHEATED STEAM.—*What advantages are claimed for superheated steam?*

Q. 4. WALLING CRIBS.—*If you were engaged in fixing a walling crib or curb in bad ground, what precautions would you take?*

SECOND CLASS.

Q. 5. METHODS OF WORKING.—*What would guide you as to the length of a wall face in working a seam of 3 feet thick and under?*

Q. 6. TIMBERING.—*Sketch the various systems of timbering with which you are acquainted, and briefly explain the circumstances suitable to each.*

Q. 7. VENTILATION.—*Give the rule and an example in estimating the work done in ventilation at a colliery by a fan.*

Q. 8. PUMPS AND PUMPING.—*What diameter of pump will be required to deal with 500 gallons of water per minute, allowing 10 per cent. off for leakage, if the effective speed of the pump is 35 feet per minute?*

FIRST CLASS.

Q. 9. SURVEYING.—*Describe a level chain and levelling staff. State for what each is used, and the means you would adopt for testing the chain.*

Q. 10. TIPPLERS.—*Describe one modern type of automatic tippler, showing the method of operating it.*

Q. 11. VENTILATION.—*What means would you adopt to ascertain if the ventilation of a mine, working with naked lights, was adequate?*

Q. 12. PUMPS AND PUMPING.—*Sketch a pump suitable for raising 6,000 gallons of water per hour through a vertical height of 160 yards, and give principal dimensions.*

Best Answers Received to Questions in No. 17, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Oil Shale.

Q. 1.—*What is oil shale, and what useful substances are obtained from it?*

A.—Oil shale is consolidated mud or clay, which has been altered by time and pressure and is found stratified in various formations. Bituminous shale, as it is called, has been found in various parts of the world. It is regarded as mineral matter, which has been impregnated largely with the products of decaying vegetation during the time of its formation. In appearance, oil shale resembles some coals, which only differ in degree, or shall we say in the quantity of vegetable matter or bye-products, which they contain. Oil shale, like coal, may be called stratified rock, containing mineral matter and other volatile products. Many oil shales have been known to yield great quantities of mineral matter, as much as 80 to 90 per cent., and in some cases 20 per cent. of other volatile matter.

Peel, in his *Coal Mining* (page 20) tells us that large quantities of oil shale are annually worked in the United Kingdom. The shale industry is carried on to a great extent in Scotland, due to the fact that it is rich in oils, both burning and lubricating oils, and many other useful substances, which make the shale industry a profitable one.

In order to ascertain what useful substances are obtained from oil shale, we know that the shale must undergo some process in order to obtain the useful substances from it. This is accomplished by what is known as distillation, which is brought about by heating the oil shale in special apparatus, or closed retorts, similar to those employed in the manufacture of gas. When oil shale is heated in the closed retorts or furnaces, a solid substance is left called charcoal or coke; also many other useful substances are brought into existence by this process.

In connection with this process of distillation, we find that many volatile products are obtained. Some of these products are permanent gases, such as hydrogen, carbon monoxide, carbonic acid gas, &c., and many hydro-carbons. In addition, we have the remaining tarry liquids, which are collected in tanks or receivers. This tarry liquid, by special processes of distillation, is found to contain various useful substances, known as light oils, medium oils, and heavy oils. After the oils have been extracted there remains something in the form of grease. This is further distilled and separated until nothing is left but pitch,

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

being used for making asphalt artificially, and the modern artificial fuel known as briquettes.

Oil shale by various processes of distillation contains many useful substances which may be related as follows:—By the distillation of shales we get many useful substances, such as ammonia, naphtha, benzene or benzole, vaseline, bitumen, asphalt, crude naphtha, and various other products. From oil shales we get many kinds of mineral oils.

Petroleum and paraffin oils are obtained in great quantities; in some instances the oil has been found dripping from the shales, and thus collected. It is useful for burning in lamps.

Heavy oils are also obtained, being utilised for lubricating purposes. Paraffin wax is also obtained for candle making.

In conclusion, oil shale, like coal, by distillation and analysis, is found to contain many useful substances. These substances can be separated by fractional distillation, and utilised for many useful purposes.

Assisted slightly by ADAM'S *Chemistry*, Chapter VIII.

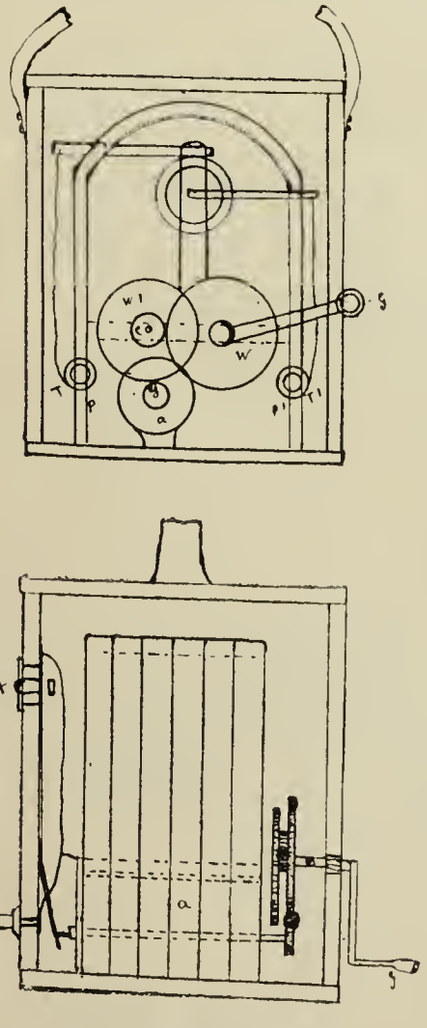
THOS. GASKELL, 138, Downall Green Road, Bryn.

L. J. Thomas, W. Glover, W. Heaton, J. Smith, Junr., J. W. Brough, A. Thomson, W. Williams, A. Moores, J. Brooks, W. Atherton, C. Simpson, J. C. Rodman (*12 marks each*).

G. Poll, T. Evans, Junr., J. E. Tredgold, D. McBurnie, T. U. Parr, G. Davies (*8 marks each*).

Shot-Firing.

Q. 2.—*Which is the best electric battery to use—high or low tension? Give reasons.*



Illustrating Question 2.

A.—The electric battery consists of an armature revolving between two poles of a set of magnets. The general scheme of the battery may be gathered from the accompanying sketches, where a shuttle armature (*a*) is shown in gunmetal bearings concentrically with soft polar extensions (*P* and P^1). The latter pieces, which serve to distribute the magnetic fluid, are enclosed by the legs of horse-shoe magnets arranged with their positive poles together on one, and their negative poles together on the other side, so as to form a powerful magnet. A high armature speed is attained by suitable toothed wheels (*W*, W^1, *e* and e^1), the main driver being actuated by a detachable handle (*g*). The opposite side of the hard wood containing case carries terminals (*T* and T^2), and a push botton (*K*). The battery is enclosed in a box of polished teak wood, and is suitable for firing high and low tension detonators. Nobels' Twist exploder is capable of firing both high and low tension detonators.

In selecting a suitable battery you also have to select the kind of detonators you are going to use, since a high tension battery is only suitable for firing high tension detonators, and the same with low tension batteries. Advantages are claimed from detonators, both high and low tension. Low tension detonators can be tested by a galvanometer before they are sent into the mine, thus reducing the liability of miss-fires, but with high tension detonators it is impossible to test them without destroying them. With high tension batteries producing a high voltage and little current, high tension detonators may be fired, and with low tension batteries producing a large current with a low voltage low tension detonators may be fired, so that the type of battery governs the type of detonator. In using a magneto exploder grip it firmly with one hand, and after connecting the wires to the terminals, turn the handle a few times sharply, and then press the firing button while the handle is still being turned. Care should be taken not to touch the terminals when firing, as when using a low tension battery there is a danger from shock. The low tension battery may generate sufficient current to do serious injury should the physical condition of the person using the battery be very weak. High tension detonators are subject to climatic conditions, as they are affected more or less by moisture and heat; on the other hand, low tension detonators are more liable to go wrong or to fail in manufacture owing to the extreme fineness of the platinum wire. Thus, considering the many conditions for selecting a suitable battery, in my opinion the most suitable for mining in coal is the high tension, but for sinking shafts I should prefer a low tension battery with suitable detonators.

Assisted by BAILE'S *Modern Mining Practice*.

J. H. CUMBERBATCH, 4, Degg's Fields, Longton, Stoke-on-Trent.

[NOTE.—The fact that there are two classes of electric battery and detonator in general use makes it difficult for the "man in the street" to say definitely which type is the better. One feature in favour of low tension caps, and, therefore, indirectly, in favour of low tension batteries, is that they alone can be tested before use, without exploding them. A feature of high tension batteries is that they can be used, within limits, to fire low tension, as well as high-tension caps, and this, of course, is in their favour. We have selected the above answer because the writer gives the conditions under which each is the better. Taking the other answers, it may be said that there are just about as many in favour of one system as of the other.—C.C.M.]

W. Heaton, C. Simpson, J. C. Rodman, T. Evans, Junr. A. Davies, W. Atherton, W. Williams, J. Smith, Junr., T. Gaskell, L. J. Thomas, J. Bradshaw (*12 marks each*).

G. Davies, J. A. Hill, J. Brooks, D. McBurnie (*8 marks each*).

Electric Terms.

Q. 3.—*Explain what is meant by the electric terms "high," "medium," and "low" voltages.*

C. Simpson, J. E. Tredgold, J. C. Rodman, T. Evans, Junr., F. Kershaw, J. Brooks, J. H. Spence, J. Cheetham, A. Moores, I. Hollins, A. Thomson, W. Williams, S. F. Middup, J. A. Hill, Geo. Winfield, F. Mitchard, T. Gaskell, G. Davies, L. J. Thomas, W. O. Dodd, J. Scott, W. Bretton, E. R. Hindle, W. Glover, T. G. Lippitt, J. Bradshaw (*12 marks each*).

Horse-Power of Engines.

Q. 4.—*What horse-power of engine would be required to raise 1,000 tons of coal in eight hours from a depth of 480 yards?*

A.—Assuming that the eight hours is the actual winding time for coal only, the number of tons to raise per minute will be

1,000 ÷ (8 × 60) = $2\frac{1}{12}$ tons. Taking the average speed of winding as 1,800 feet per minute, or 30 feet per second, one wind will take $\frac{480 \times 3}{30}$ = 48 seconds, and allowing (say) 10 seconds for banking we have 48 + 10 = 58 seconds per complete wind. As we have to wind $2\frac{1}{12}$ tons per minute, every wind we must raise $\frac{58}{60} \times 2\frac{1}{12} = 2$ tons (nearly).

Now, find the weight of the rope. The cage will weigh as much as the coal, and reckon the tubs to weigh half as much.

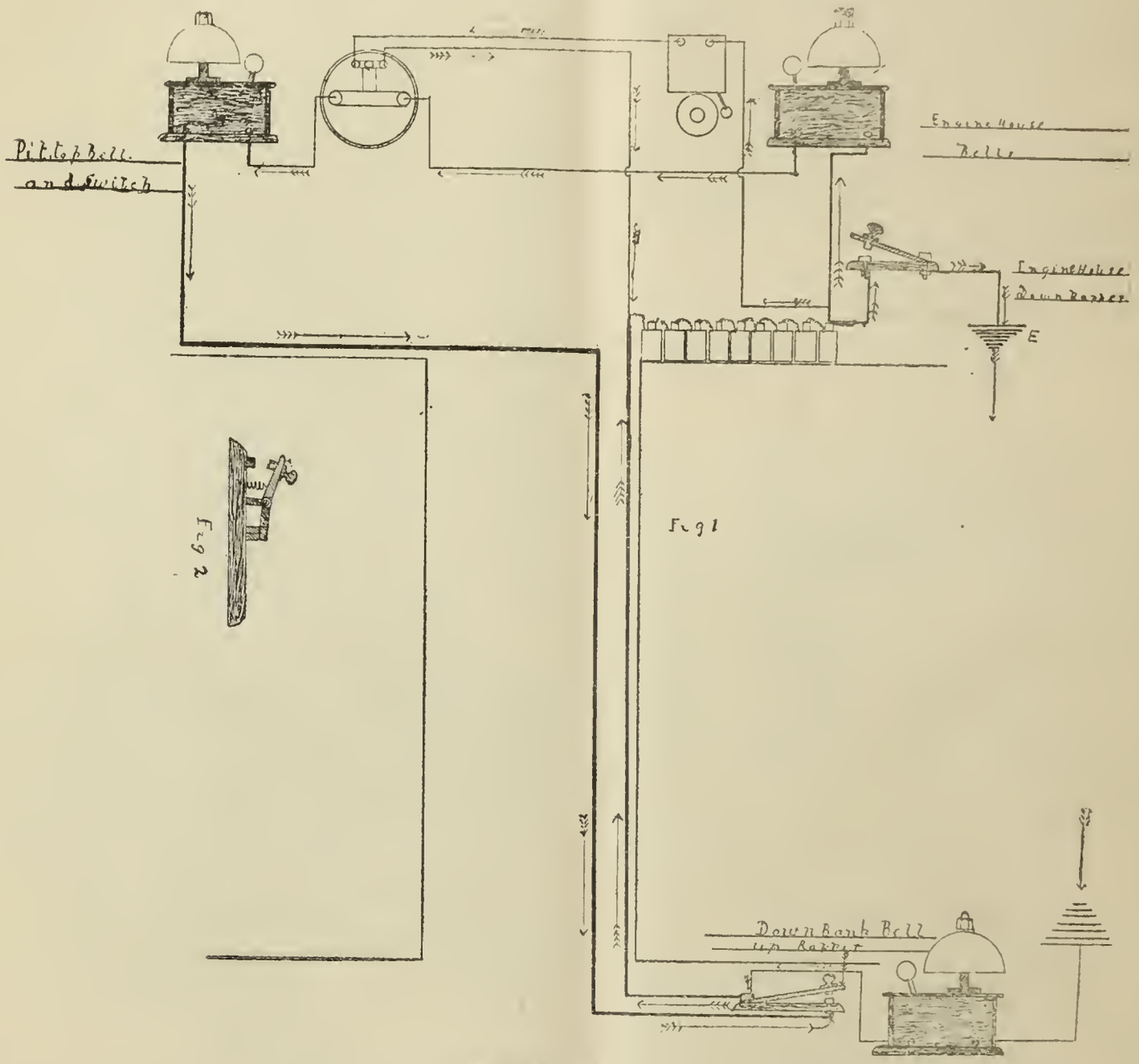
It will be seen that the cages and tubs will balance each other, therefore, the engines have only to lift the coal and the rope, which is 4,480 + 4,094 = 8,574lb.

The horse-power of the engine will be

$$\frac{T \times V}{33000}.$$

Where T = total weight on engines;
V = velocity in feet per minute.

Then



Illustrating Question 5.

We have 5 tons or 11,200lb. at the end of the rope. Now

$$W = \frac{L}{1792 - D}.$$

Where W = weight of rope per yard in lb.;
L = total load at end of rope in lb.;
D = depth of shaft in yards.

Then

$$W = \frac{11200}{1792 - 480} = 8{\cdot}53\text{lb.}$$

Therefore, the total weight of the rope hanging in the shaft will be 480 × 8·53 = 4,094lb.

$$\frac{8574 \times 1800}{33000} = 468 \text{ H.P.}$$

Owing to the intermittent work of the engine, the attaining of a high speed in the shaft and other considerations, I would make one cylinder of the winding engine equal to this horse-power, therefore, the total horse-power required would be 468 × 2 = 936 H.P.

Indebted to back numbers of *The Science and Art of Mining* for assistance in the preparation of this answer.

JOHN A. HILL, St. John's Chapel, Co. Durham.

[NOTE.—The majority of answers merely give the theoretical horse-power represented by the raising of the coal in

the given time, taking no account whatever of the weight of rope to be lifted, friction of engines, and other contingencies. If it were necessary to adopt or design a pair of engines to do the work in the question the engines would be made of such a size as to give not less than 1,000 horse-power.—C.C.M.]

T. Telford, W. Atherton, F. Taylor, J. H. Cumberbatch (*12 marks each*).

J. Bradshaw, J. Lawrie, Junr., W. Glover, W. Bretton, F. Mitchard, J. Smith, Junr., J. W. Brough, S. Beardsley, J. H. Spence, J. Brooks, J. L. Hughes, A. Davies, E. J. Baber, C. Simpson, J. C. Rodman, W. May, J. E. Tredgold, S. F. Middup, E. R. Hindle (*8 marks each*).

G. Poll, T. Evans, J. Ridgeway, F. Kershaw, T. J. Hay, A. Moores, T. Douglas, I. Hollins, W. Williams, A. Thomson, D. McBurnie, G. Winfield, T. U. Parr, T. Gaskell, G. Davies, D. McCarely, W. O. Dodds, J. Scott (*4 marks each*).

SECOND CLASS.

Signalling.

Q. 5.—*Describe the best method of signalling you are acquainted with* (a) *in sinking shafts;* (b) *in winding shafts.*

A.—In the most modern mines, some of which are sunk to great depths, electric signalling finds a great deal of favour in communicating from the shaft bottom to the surface, as the signals can be given more rapidly and with greater precision. The old ordinary hammer is employed at some mines of shallow depths up to about 100 fathoms, but beyond this depth it is better to use the electric signal. The power used for electric signals is generally obtained from a number of Leclanche cells, the number used being according to the resistance to be overcome. As General Rule 8 does not apply to winding shafts unless winding is being carried on in the upcast, the stipulated voltage must be adhered to, viz., 250 in any one circuit.

The best method of signalling which I am acquainted with is shown in sketch. It can be equally applied in sinking shafts and winding shafts, only as the sinking proceeds the live wires will be required to be carried forward. For electric signals in sinking or winding shafts I would prefer the single stroke bell, both on surface and at shaft bottom, as the signal is much better and distinct. The sketch shows the single stroke bells on pit-top and in engine house. These bells, where winding operations are carried on, will ring simultaneously as shown by diagram when the switch on the pit-top closes the circuit. The low resistance trembler in the engine house connects the engineman with the banksman. When the banksman communicates any signal to the engineman the engineman can only receive that signal, as the switch on an arrangement of this description would only require one man and the putter in, as automatic greasers would be used underground.

Peter Wilson, 54c, Elizabeth Street, Workington, Cumberland.

[NOTE.—For giving definite and distinct signals there is nothing superior to the single stroke electric bell. The one point in which the "trembler" has the advantage lies in the fact that if the wires are in contact anywhere up the shaft the bell will continue ringing, until, of course, the batteries run down, and thus give notice that there is something out of order. We always advocate a wire and knocker arrangement to be kept in a shaft in case the electric signals should get out of order. This is also the kind of signal which we prefer for a sinking pit. It can be easily lengthened, and besides, it is not liable to damage through shot-firing, as is an electrical installation.—C.C.M.]

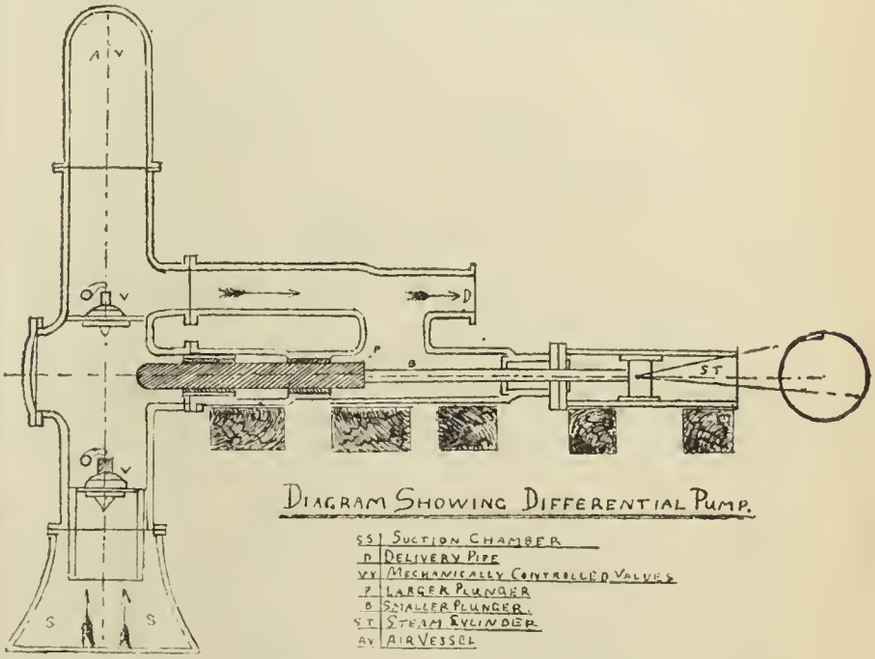
A. Nelson, W. H. Brealey, R. Graham, A. Stephens, E. Ambrose, J. Grundy (*12 marks each*).

Pumps and Pumping.

Q. 6.—*Describe the principle of the differential or telescopic pump, and say how it is applied in deep mines.*

A.—The requirements of this question are somewhat doubtful, the only connection the term "telescopic" has in pumping (as far as the writer is aware) is in sinking pumps which are sometimes provided with sliding or a telescope suction pipe, to reduce the inconvenience of constantly lowering the pump itself. Again, when considering the first term, viz., differential, we naturally think of the pump introduced by Professor Riedler, of Berlin. However, I intend discussing the latter, as it is *the* pump in deep mines.

As seen in the sketch, its action can be readily understood. It is double-acting, and is specially suitable in deep mines. Unlike ordinary double-acting pumps, it has only two valves—one suction and one delivery—therefore, the pump has less moving parts, and the efficiency is enhanced. The most important feature of this pump lies in its valve action. The valves open automatically, *i.e.*, by the action of the water underneath them, but are closed *at the proper instant* mechanically—by means of a specially designed controller, conducted from the engine shaft. The advantages thus obtained are numerous: (1) Slip is considerably reduced, with a consequent increase in efficiency; (2) the water is not unnecessarily impeded while on its journey; (3) water hammer and shocks are practically avoided, and thus wear and tear, especially of the moving parts, is greatly reduced. While the piston or plunger is making its backward stroke (to the right in sketch) the upper valve leading to the delivery main is closed (by the little fork just above it actuated through the medium of the controller) at the proper instant, independent of the reaction of the water which must occur immediately the plunger completes its forward stroke. Immediately the plunger has completed its backward stroke the suction valve is mechanically shut at the proper instant, and this process is repeated as long as the mechanical controller



Illustrating Question 6.

is kept in repair. The tappets or forks above each valve must be carefully protected and supervised, otherwise dirty water will soon have effect, either in totally "clogging" them, or destroying their accurate action.

The action of the pump may be briefly stated as follows:—The plunger on its forward stroke (to the left) forces the water before it, through the delivery valve *V*, and into the delivery main, as indicated by the arrows; half the discharge passes through the pipe *D*; the other half lodges in the barrel *B*. On its return stroke the *difference in area* of the two sections of the plunger discharges the water in the chamber *B* through the delivery pipe *D*; the result is obviously a double-acting pump. This constant delivery of water makes it well adapted for high lifts, which will have to be considered in future mining operations.

As seen in the diagram, the plunger proper consists of two sections. The outer one *P* is twice the sectional area of *B*, therefore it is apparent that half of each delivery of water will accumulate in this difference of area as said above. On account of the valve arrangement of this pump it is usually worked at a high speed, from 90 in the larger sizes to 140 or 150 in pumps of smaller capacity. Pumps generally do not allow

of being driven direct by means of a motor, on account of the great difference in speed between the two, but in the case of the Riedler pump this direct coupling is possible, and, therefore, this adaptation of speed is very important in increasing the efficiency. As regards the larger sizes, the connection may be obtained either by means of a belt or rope, and it is urged that these provide an elastic medium between the somewhat impulsive action of the pump and the uniform motion of the motor. The introduction of this kind of pump enables a more extensive employment of electricity, for it provides a closer adaptation of speed, which is essential for efficient working of electricity.

It is provided with a barrel-like air vessel, fixed above the delivery valve; it is also convenient to have another formed round the suction, as shown in the diagram. These store up energy and impart it back to the water when the delivery is checked by the reciprocating motion of the plunger. Therefore, a constant delivery is maintained.

If I had the option of driving this pump, a three-phase induction motor, direct coupled, would be installed; seeing that it possesses no commutator, sparking is practically absent. The power could be conducted by means of a three-core cable, with good insulation. If the roadway along which it was carried was extensively used for haulage and travelling purposes, I should place the cable in prepared wooden boxes, provided with troughs in which it may rest. The box should then be well covered with pitch, not that it is a good insulator, but it will prevent damage to the cable when the top is not of a strong nature.

This answer is strictly original; the sketch is drawn from memory.

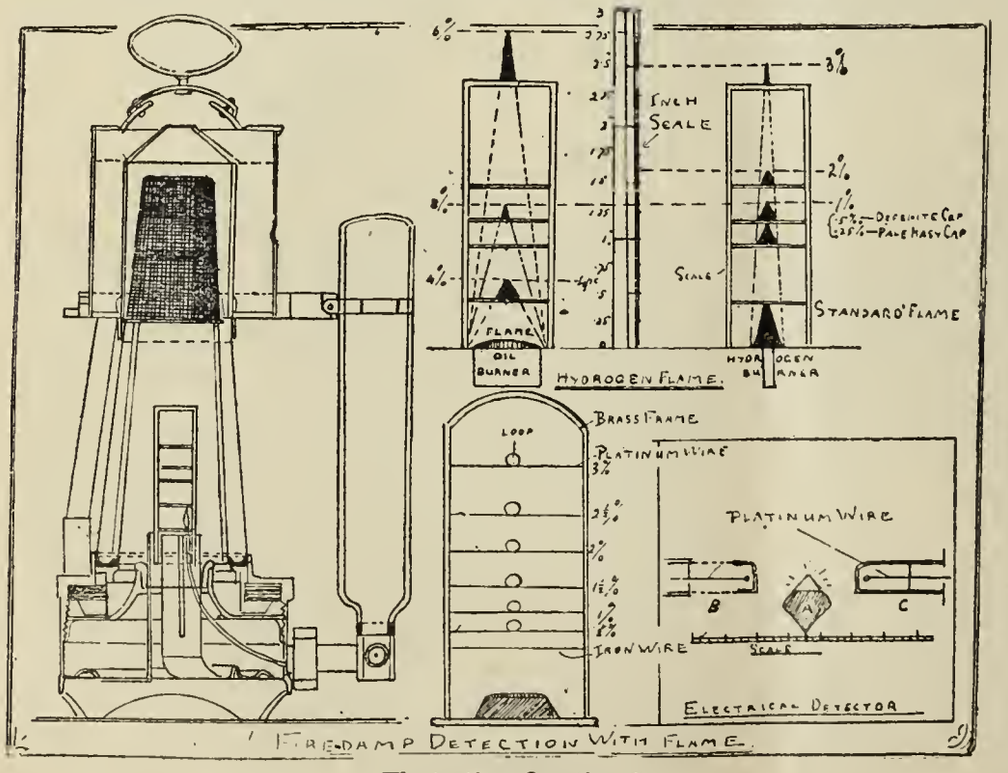
A. Nelson, Maes-y-Dyffryn, Glyn Neath.

A. Stephens (*12 marks*).
E. Ambrose (*8 marks*).

Gases in Mines.

Q. 7.—*What methods are employed for detecting the principal gases met with in coal mines? What proportion of atmospheric air renders them harmless?*

A.—The estimation of fire-damp in mine air consists chiefly of observing the behaviour of the flame of a protected lamp when introduced into the atmosphere supposed to contain inflammable gas. Testing the air should, strictly, be divided into (*a*) testing in air which is supposed to contain large percentages of gas; and (*b*) testing when it has been proved by experiment that the percentage supposed to be present is very minute. Therefore, the first operation is to see what amount of gas is likely to be present, which can readily be done by the use of an ordinary miner's safety-lamp; if the lamp shows no sign of gas, then recourse must be had to more scientific and sensitive methods. Practically every miner is familiar with the appearance of the "blue cap," and a device whereby this phenomenon is employed appeals more strongly to the majority than any other apparatus. There prevails no doubt whatever that for any instrument designed for gas detecting underground, simplicity is most important, and the "cap" test possesses this qualification to a high degree, but, as in many other cases, simplicity and accuracy are not synonymous terms, and every gas detector utilising it suffers greatly from three defects: (1) The personality of the operator enters into every determination, *i.e.*, one person may easily see the action of gas upon a flame, even with low percentages, whilst another with the same lamp could see nothing unusual, in some cases colour blindness, eye troubles, and nystagmus being responsible. (2) The cap as employed to measure small percentages of gas must, to enable reliable results to be obtained, be maintained of a uniform height. (3) With some lamps a cap may be perceived when ·25 per cent. of gas is present, yet if the lamp is raised into a higher zone containing ·5 per cent. (100 per cent. increase), the resulting elongation of the cap is hardly perceptible. When testing with the ordinary lamp the flame is lowered until only a speck of yellow is to be seen, and the size of the yellow speck forms the criterion on the size of the test flame; so that the flame can be reset to the standard height each time an examination is made. The more delicate gas-testers, however, employ a large flame as a testing flame; its standard height can only be procured in fresh air (in the intake or near the bottom of the downcast shaft), and it should not be re-adjusted in air likely to contain impurities, on account of the effect of "spiring"; therefore, we can never be certain whether, in examining the air, the flame has crept up or worked down a little. The height of a cap over a flame when enveloped by a gaseous mixture depends directly on—(1) The length of the flame or standard height; and (2) the intensity of the flame. At this stage in dealing with this matter I acknowledge indebtedness to GREENWELL'S *Pocket-Book*. In the first case, all improvements on the original Davy (burning colza) so as to make the lamp a better gas detector, were based on the first of these conditions, or on both in combination. As gas-testers, the lamps usually employed in this country may be said to be improvements on the Davy by the use of different oils, or mixtures of oils, giving a flame of higher intensity than the Davy. The improved Gray lamp is also an improvement upon the Davy, but a higher temperature flame, that of benzoline, is used in it; it enables a careful operator to detect about 1·5 per cent. of gas. The same may be said of the Wolf (benzine) lamp, which also can detect about 1·5 per cent. Of the lamps designed to take advantage of both of these facts, *i.e.*, length and heat of flame, must be classed the alcohol lamps of Pieler, Chesneau and Stokes, and the hydrogen lamp of Clowes. Of the alcohol lamps in this country the best known is the Pieler. This is a gas-testing lamp pure and simple, and, therefore, an ordinary lamp must be carried with it as an auxiliary. This lamp is capable of detecting as low as ·5 per cent. of gas.



Illustrating Question 7.

Originally, the Pieler lamp may be described as a large unprotected Davy, in which alcohol is burnt in place of colza, a round wick, preferably of silk, being used. The flame burns inside a short chimney, which serves a double purpose, namely, shielding the eyes from the faint rays of the flame, and forming a means of adjusting the flame to a standard height (1·2 inches); the tip

of the flame being set exactly on a level with the top of the chimney, in gas-free air, previous to commencing any tests. This lamp is greatly improved by enclosing it in an iron shield possessing a graduated glass or mica window. With this addition, introduced by Mr. W. N. Atkinson, the lamp is rendered suitable for use in moderately rapid air currents, and also providing a ready means of reading off, to a fair degree of accuracy, the gas percentage as indicated by any length of cap.

Next is the Clowes' hydrogen lamp (see illustrations), a very scientific and delicate gas-tester based on the flame test. In reality it is an A.H.G., fitted with a gas-testing attachment. It owes its excellence and delicacy to the employment of the hottest and least luminous of all gaseous flames, namely, that of hydrogen. In both of these respects, therefore, it forms the highest development of this class of gas-detectors. In *Figure 1* is shown a vertical section through the instrument. It shows the small detachable cylinder containing compressed hydrogen at the side. This supplies the small hydrogen flame (shown burning in the sketch) when examining the air for fire-damp. The flame is adjusted to the standard height by means of the stop-cock and key. When the lamp is not employed for gas-testing the cylinder is detached and carried in the pocket. The lamp then becomes little else than an ordinary A.H.G. In endeavouring to measure the percentage of gas present by means of the ladder, the eye has not only to distinguish the exact apical point, but also as to the distance, 0·2 inch; whereas, if it happens that the percentage lies between those indicated by two adjacent rungs of the ladder, the eye has further to estimate the interval—an operation complicated by the fact that the rungs are at gradually increasing distances apart. This lamp will detect 0·2 per cent. of gas, and as a means of *detecting* small proportions of fire-damp it is really the very best instrument of its kind. In all cases whereby the blue cap test is used, the results are invaluable as far as *detection* is concerned, but as a means of *measuring* those detected quantities they are not, unfortunately, so reliable.

The percentage (referring to Clowes lamp) is determined as much from the brightness as from the height shown by the cap.

In the illustrations is shown the so-called "electrical detector" of Professor Liveing; the principle may be gathered from the simple diagram. *A* and *C* are precisely similar spirals of platinum wire, which are connected in series to a magneto-electric machine, by means of which they may be heated to a dull glow. *C* is enclosed in a glass vessel containing pure air; *B*, on the other hand, is accessible to the surrounding atmosphere by being enclosed in a gauze casing, having a glass front. Rays from the glowing spirals illuminate the opposite sloping faces of the block *A*, the sides being covered with white paper. If no gas is present the spirals will glow equally brightly, and the block will have to be adjusted exactly midway between them, so as to have the sloping surfaces equally illuminated. If a small percentage of gas is present the brilliance of *B* increases, due to the fact that a hot wire has the property of slowly burning out the fire-damp from the air in its vicinity; therefore, in order that the sloping surfaces of the block *A* shall be again equally illuminated it must be moved in the direction of *C*, and by means of a scale underneath graduated by trial experiments in various mixtures of gas and air.

What Proportion of Atmospheric Air renders them Harmless?

Fire-Damp.—The actual proportion of fresh air necessary to so dilute this gas as to render it harmless can only be determined by discussing its effects upon the system at certain percentages. The effects produced are those produced by a diminution of oxygen. According to the new Coal Mines Act any current which contains upon examination more than $\frac{1}{4}$ per cent. of fire-damp must be considered dangerous, and not free from gas, therefore to render ·25 cubic feet of fire-damp harmless we must have $(100 - \frac{1}{4})$ $99\frac{3}{4}$ cubic feet of atmospheric air to mix with it. If we have 1 cubic foot $(\frac{1}{4} \div \frac{1}{4})$ we must increase our air supply four times, or $99\frac{3}{4} \times 4 = 399$ cubic feet, &c.

Carbon Dioxide.—The actual percentage of this gas in mine air, or strictly speaking fresh air, is 0·03 per cent. by volume. According to the above Act, a working place is not inhabitable when the CO_2 exceeds $1\frac{1}{4}$ per cent., therefore, for every $1\frac{1}{4}$ cubic feet of CO_2 we must supply $(100 - 1\frac{1}{4})$ $98\frac{3}{4}$ cubic feet of atmospheric air, or if we desire to have a safety margin of not more than 1 cubic foot of CO_2 in the air, we must have (100 — 1) 99 cubic feet of fresh air to render it harmless.

Carbon Monoxide.—The highest allowable limit for this gas in the air is 0·05 per cent., therefore, if 0·05 cubic foot of this gas exists anywhere, a supply of (100·00 — ·05) 99·95 cubic feet of fresh air is essential to maintain safety. If 1 cubic foot is present a supply of (1·00 ÷ ·05) 99·95 × 20 = 1,999 cubic feet of atmospheric air is necessary to render it harmless.

Sulphuretted Hydrogen.—Even 0·05 per cent. of this gas is capable of producing alarming symptoms upon a man. It should never exceed ·01 per cent. in any case, and it is questionable whether this minute percentage is harmless. Thus, ·01 ($\frac{1}{100}$ of a cubic foot) requires 99·99 cubic feet of air, whilst 1 cubic foot of this gas will require 99·99 × 100 = 9,999 cubic feet of air to render it harmless.

Latter part of answer is original.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[Note.—The chemist is going to play a big part in the future in connection with gas testing in mines. He will take samples of air underground, and in the laboratory discover correct to two places of decimals the percentage of oxygen, carbon dioxide, carburetted hydrogen, carbon monoxide, sulphuretted hydrogen, and nitrogen present in such sample. But he must be thoroughly conversant with the work. We have seen a little amateur testing, and it was not at all convincing. Unless the tester is a thoroughly competent analyst, we should prefer to pin our faith to testing by the hydrogen flame; at any rate, as far as fire-damp is concerned. As we said in our remarks recently, when comparing the theodolite with the ordinary dial, seeing that the theodolite is so much finer an instrument than the dial, and, therefore, capable of much more exact results under suitable conditions, it is at the same time, and perhaps as a natural consequence, far more capable of error if carelessly used. In the same way we believe that the chemical analysis of mine air, if unskilfully carried out, is capable of bigger blunders than the ordinary flame tests, although, if properly employed, it will give us far more exact results. Of course, we must not forget that the flame test is no use for the testing for percentages of any of the other gases, although it will give some indication of their presence, especially in the case of carbon dioxide. —C.C.M.]

A. Stephens (*12 marks*).
E. Ambrose, R. Graham (*8 marks each*).

Surface Arrangements.

Q. 8.—*What inclination would you lay your railway sidings under the screens on the surface? What inclination would you lay your rails at pit-eye for full tubs?*

A.—It must be remembered that, especially in the case of trams, the gravity force of the full tram must be sufficient to overcome all its resistances, and also possess a surplus power to set in motion and gain enough speed or acceleration to make the employment of manual labour unnecessary. Another important point is that the necessary force at the commencement from the pit-eye must be capable of overcoming the inertia of the tram; once having gained speed, the force then necessary to maintain motion is not so great, the only force required being that capable of overcoming the friction of the wheels and in moving through air. But, seeing that the force is constant throughout the length of road (providing the gradient is constant), this tends to accelerate the speed of the tram, hence, these facts must be kept in mind when determining inclinations for any mine wagon or tram. To surmount the undesirable feature of this acceleration during the completion of the journey towards the screening plant, it is usually wise to modify the inclination towards the screens. Also the steepest part of the roadway should be at the top, which will enable the full load to accumulate extra power at the commencement, and the reduced gradient at the bottom of the road near the screen will assist in the retardation of the trams as they approach. Usually the trams, after running by gravity to the tippler at a gentle inclination, are elevated to a sufficient height to enable them to run back to the shaft by gravity. For this purpose a vertical lift or a creeper is employed. The inclination from

pit-mouth will depend to a certain extent upon the type of tram used, method of lubrication, and type of rail used. When the tippler is no great distance from the pit-mouth a fair starting gradient is 1 in 42, which will provide the necessary starting of the tram and for accumulating acceleration. Locking or spragging is resorted to for retarding them. If the roadways are fairly long, and moderately clean, 1 in 50 to 1 in 58 is common. For T-head rails, clean and well laid, and providing the run is long, a gentler gradient, such as 1 in 70, may be successful. To ensure success of the easy working of trams from pit-mouth, the rails must be well laid, and as straight as possible, as a tortuous road greatly assists in the derailment of trams. The gradient must be considered too low if it causes the trams to stop on the run, and will, therefore, require pushing; on the other hand, a steep gradient tends to accumulate too great a velocity, and difficulty will be experienced to arrest them. A good idea as to the coefficient of friction of the wagon is of great importance in determining gradients. The resistance to traction through friction at the axle is equivalent to $L \times C \times A$, where L is the total load on axles; C coefficient of friction; and A ratio of axle diameter to diamater of wheel. In addition to this, we must consider the friction due to the rubbing of the wheel on the rails. This may be neglected for practical purposes (being only about $\frac{1}{1003}$ portion of the total load), but in the case of rails being almost covered with dirt and small coal, and the rails' surface sunk below the sides, the resistance thus introduced is very considerable. Consequently, it is economical in all cases of suitable gradients to maintain clean rails, and well elevated above the surrounding ground. Of course, in certain cases, such as where the gradient is made of necessity steep (on account of surface undulations), and it is found that trams gain too high a speed, the rails are usually covered with a fine coating of sand or dirt. Where curves are negotiated the gradient must be steeper, 1 in 30 to 1 in 35 being usual. Curves vary from 6 to 16 feet radius—for easy running they should never be less than 8 feet; a common radius is 10 feet.

The sidings underneath the screen are usually laid according to the capacity of the wagons. For 12 tons capacity, which is common in this country, an inclination of 1 in 75 in favour of the load is very suitable. For 50-ton wagons, common on the Continent, 1 in 90 to 1 in 100 is sufficient, if kept clean. For use directly under screens, where no rope is used for moving the wagons, 1 in 60 is most usual, and lowered to 1 in 70 and 1 in 90 as the length of the sidings increases. At a colliery I am acquainted with the inclination at the sidings, for 12-ton wagons, is 1 in 80, and it works successfully. The above gradients will be found too low for wagons not properly lubricated, but in the case of trams the slope must be made for the sluggish and bad running ones; the easy running trams often require spragging.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[Note.—We have always been led to believe that an inclination of 1 in 100 or thereabouts, was a very convenient inclination for railway sidings under the screens, where it was possible to have one's choice. Of course, in some cases where the ground rises rapidly a greater gradient than this is necessary; in fact, we know of one case where the fall is almost 1 in 30. It must always be remembered that the inclination under the screens is also the inclination up which the empty trucks will have to be pushed by the locomotive, and on this account alone we should aim at having no more inclination under the screens than will just allow of the trucks to move under the influence of gravity.

As regards the gradient of the rails at the pit-eye for the full tubs, small tubs holding from one-third to one-half of a ton will run on an inclination of about one inch to the yard, or 1 in 36. Large trams, such as are used in South Wales, holding from a ton to 30 hundredweight, will run if well greased on an inclination of two-thirds of an inch to the yard, or 1 in 54. These inclinations apply only to perfectly straight roads; if there are curves in the roads the inclination must be increased; in fact, around very sharp curves it will be necessary to give a fall of nearly 3 inches to the yard in order to get the tubs to move under the influence of gravity alone.—C.C.M.]

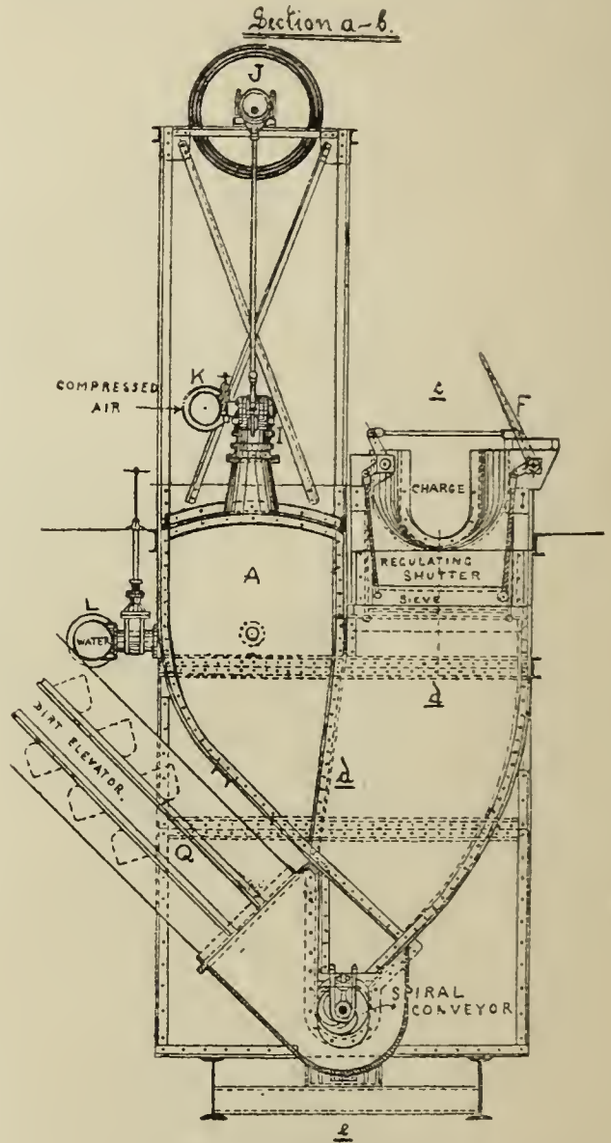
J. Grundy, E. Ambrose, A. Stephens (*12 marks each*).

FIRST CLASS.

Coal Washing Machine.

Q. 9.—*Describe and sketch the coal washing machine with which you are best acquainted.*

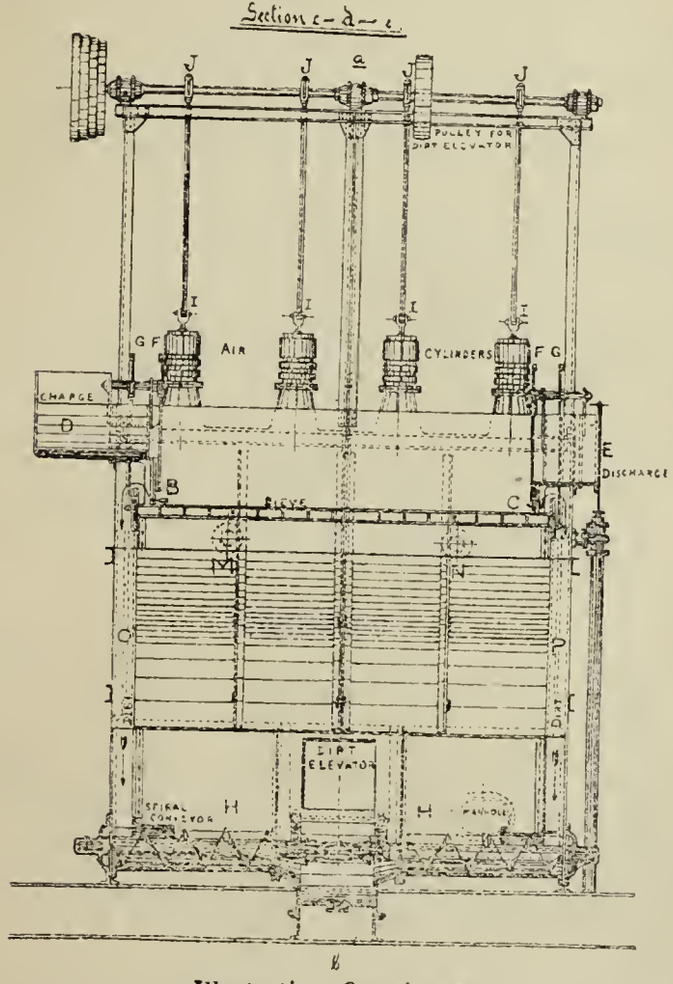
A.—Owing to the gradual exhaustion in this country of the finest and cleanest seams of coal it is becoming necessary, and will be more so in the near future, to work the thinner and dirtier seams. Mr. F. Baum, of Herne, Westphalia, who has devoted himself for the last quarter of a century to the questions of screening, sizing, and washing of coal, is responsible for what may be described as one of the most perfect systems of coal cleaning. Formerly the Baum system, like most others, consisted in the preliminary classification of the coal into several sizes for the different washers. Latterly Mr. Baum has adopted the principle of "wash first, then classify." The particulars given below appear in the *Mechanical Equipment of Collieries*, by C. M. Percy, and, together with the sketches, were placed at his disposal by Messrs. Simon-Carves, Ltd., of Manchester, the representatives of the Baum washer in England.



Illustrating Question 9.

The pulsating or jigging washer used in the Baum system relies upon compressed air, instead of a piston, to effect the pulsation of the water. The air, compressed to one and a half to two pounds per square inch, is delivered to the air-tight compartment A, forming the left side of the washer, by the pipe K. The admission is controlled by a piston valve I, worked by the eccentric J. It will be understood that during the time the piston valve admits the compressed air to the chamber A, the water on that side is rapidly depressed, simultaneously rising in the other compartment, where the washing takes place. When the piston valve closes against the admission of compressed

air, it allows the air already delivered to escape into the outer atmosphere. It will thus be evident that whilst the water with the mixed or unwashed coal rises quickly, under the influence of compressed air, it falls slowly, merely due to the inch or two of difference in the level of the water in the two compartments. In this way the suction action, common to washers with a piston, is avoided, together with its objectionable features. Instead of the coal and shale being drawn back in a more or less compact mass, by the suction effect of the piston in its upstroke, in the Baum washer the downward movement is so slow and gradual that, as a matter of fact, the smallest pieces of coal do not appear to sink at all, but to remain floating or suspended in the water.



Illustrating Question 9.

Washing Machine.—The Baum Washer is one which washes from 0 to 3¼ inches without preliminary classification. In its general construction the washing machine on the Baum system is similar to that of the well-known pulsating washers, with much larger dimensions, but the essential difference is that the pulsating motion is obtained by the action of the compressed air (4 feet water-gauge) which acts upon the surface of the water in compartment *A* in such a manner that the movement is more elastic, but nevertheless more energetic than that obtained by a piston. The pulsating motion in the front compartment of the washing machine is quicker in the upward than in the downward movement. This is effected by a constant inlet of water into the compartment *A* at *M* and *N*. The pulsating motion, combined with the movement of the water running through the washer, is such that the coal, when passing into the front compartment of the washing machine on top of the sieve *BC*, and going from *D* towards *E*, is classified in layers according to specific gravity, the heavier particles sinking to the bottom. The lower layer, composed of dirt and shale, is mechanically taken out at *B* and *C* through apertures of which the height is regulated by levers *F*. After having passed through these apertures the shale has to pass over a dam, of which the height is regulated by means of levers *G*.

Having passed through the apertures *B* and *C* the dirt falls to the bottom of the washing machine through the openings *O* and *P*. From there it is taken by two Archimedian screws *H*, and an elevator *Q* with perforated buckets to allow the water to run off. The admission and exhaust of the compressed air are regulated by sliding valves *I*, actuated by the eccentrics *J*. These valves are situated between the pipe *K* (conveying the compressed air) and the compartment *A*.

The coal is introduced by means of a current of water into the front compartment of the washing machine at *D*. The water necessary for the washing process is clarified and carried by the pipe *L*, which introduces it at *M* and *N*.

Classifying Drum.—The exit of the washing water and of the washed coal is effected at *E* through a trough which leads the whole to a classifying drum of large diameter, and with superimposed sieves, where the screening is facilitated by a current of water, which forces the coal through the holes of the different sieves of the drum. This peculiarity explains the good results obtained by this apparatus. Each size of coal is then led through troughs to the bunkers for loading into wagons, after having received a quick rinsing with fresh water, and a passage over metallic gauze, which allows the water to run off.

Re-Washing of Fine Coal.—The fine coal (under say, ½ inch) is taken with the washing water underneath the classifying drum by a centrifugal pump, which sends it to another washing machine similar to the one described above, where it is washed again before being sent to a draining conveyor.

Separation of Intergrown Coal.—If the quantity of coal contained in the intergrown coal and dirt is only insignificant, the intergrown coal is simply allowed to go away with the dirt. If, however, the quantity of coal is important, the intergrown coal is separated from the dirt, and in that case the coal, after having passed through the first washing machine, is sent to a second washing machine similar to the first, in which the lower layer will be formed by the intergrown coal, which is recovered as described above.

Separation of the Dirt out of the Intergrown Coal.—It is sometimes advisable to crush the intergrown coal in order to effectively separate the dirt from it. In that case the crushed intergrown coal is mixed with the fine coal before it enters into the last washing machine.

The draining plant is able to reduce the added mixture in the coal to such reasonable percentage as may be required. At the same time it clarifies the washing water by extracting a great part of the slurry by filtration through a constantly renewed layer of fine coal. The settling tanks are established in such a manner that the slurry still contained in the washing water, after its passage through the draining conveyor, is automatically and continuously recovered. The slurry falling to the bottom of the tank, is continuously extracted in the form of liquid mud through a pipe which takes it to the draining pipe if it is clean, and where it remains with the fine coal, or if it is too dirty it is sent into tanks of small area, outside the washer, where it is collected, and used when and where the colliery finds it advantageous.

WALTER HEYS, 1, Walter Street, Huncoat, Accrington.

F. Hutchinson (*12 marks*).

Surveying.

Q. 10.—*How would you lay down a short underground survey on the surface, starting from the shaft? If the ground was steep, how would you lay off the lengths of the bearings?*

A.—A method commonly used in practice of laying down the underground survey on the surface is by means of the magnetic needle. Much can be said in favour of this method, although not generally advocated, where the readings can be taken absolutely free from attraction. Where it is impossible to obtain these readings, and also where the available shafts to the same seam are at a considerable distance apart, it becomes imperative to resort to the use of lines down one or both shafts, or to the use of a theodolite for taking sights down the shaft. Notwithstanding the many drawbacks to suspending wires down the shaft due to vibration, where the shafts are a a considerable distance apart, it is admitted to be the best method known. Without detailing any special features of either system the one I intend to describe is the transit-theodolite method,

Let the underground survey be completed at the shaft bottom. The instrument is then set up in this position at the bottom of the shaft, and in such a manner as to enable its telescope to be pointed upwards in the requisite vertical plane. It is necessary here to state that a diagonal eye-piece is employed with this instrument, consisting of a small right-angled glass prism, placed at the end of the telescope, and which reflects the line of sight from the plane of hypotenuse vertically upwards.

Setting up the instrument in the centre of the shaft it is then carefully levelled, and the greatest precaution taken to see that the theodolite is in perfect adjustment so as to ensure the telescope revolving in a vertical plane. The instrument in this position is in an exact line with the last sight taken. The telescope is now directed to an object, usually a small light, placed at a point at the top of the shaft and exactly coinciding with a similar point at the bottom of the shaft, which must be one of the points in the last bearing. We may term this point at the top of the shaft *A*. The vertical circle is now clamped, and the telescope again directed in a vertical plane up the shaft, but to a point diametrically opposite to the last point at the top of the shaft, and corresponding with the last point taken in the last bearing underground. We may now place two permanent marks at these two points, *A* and *B*, and I venture to say that if the greatest care be taken to ensure these two points being in perfect alignment with the two points underground, both the points at the top and bottom will be in the same vertical plane.

If we now wish an instrument may be set up on the surface and a line, corresponding to that underground in length and direction of bearing, set up cutting the points *A* and *B* to *C* according to the length, the operations being repeated precisely the same as in the mine. Permanent station marks may be put up at each station corresponding with the same stations underground. Another method of laying down the survey on the surface is by trigonometrical calculation of the bearings made out and measured out. This entails careful calculation if the bearings are to correspond in every detail with the survey book of the underground traverse. In fact, all operations in laying down the survey on the surface require the greatest care.

As regards the second part of the answer, it is a well-known fact that in chaining down a slope of any kind the measurements taken on the incline cannot be correct for horizontal purposes. In other words, instead of obtaining the hypotenuse of a right-angled triangle, what we require is the measurement of the base line. There are several methods of doing this, and the first is "stepping" the chain. This method of obtaining the horizontal measurement is very expeditious, but only approximate results can be obtained, and it is generally only employed on gently sloping ground. The chain is held and pulled taut whilst raised to the horizontal position, meanwhile holding a staff perpendicular against the chain or otherwise sticking the staff vertically in the ground. Instead of using the staff an arrow may be dropped from the chain, when in the horizontal line, to the ground, and the position where the arrow strikes gives the distance required. A plumb bob or a piece of chalk may also be used for this purpose. It will thus be seen that errors are liable to occur, and in order to reduce these as much as possible a spirit level is employed with the chain to ensure as near as practicable its being held in a horizontal position. Where the ground is too steep this method is carried out by means of $\frac{1}{2}$ or $\frac{1}{4}$ chains. Where accurate measurements are to be made, probably the best method is to obtain the angle of inclination by means of a clinometer or other suitable instrument, and the actual horizontal measurement can be ascertained by calculation. Thus: Cos of the angle of dip × hypotenuse = horizontal distance. Suppose the first measurement taken on the slope to be 300 links, and the angle of inclination to be 30°, then the correct horizontal distance is equal to $300 \times \cos 30° = 300 \times \sin 60° = 300 \times \cdot 866 = 259 \cdot 8$ links.

There are now many instruments fitted with an external arc for obtaining the angles of inclination simultaneously with the horizontal angles, thereby saving calculation.

A most convenient method is to measure along the slope and to make deductions for each length, the amount of that deduction being according to the rate of inclination, and generally derived from tables given for that purpose. Thus, assuming same conditions as before, an angle of 30° of dip is equal to about 1 in 1·7, and the correction to be made for each chain length is 13·4 links, therefore deduction for 300 links is equal to $13 \cdot 4 \times 3 = 40 \cdot 2$ links, as before.

This deduction is obtained, for each measurement if required, and may be deducted by pulling the chain backwards or forwards if necessary, through a distance equal to the required correction.

Fred J. Aston, 24, Cooper's Lane, Haydock.

[NOTE.—We must admit that we have never seen the operation mentioned actually carried out, and granted that our surface plans are correct, we do not see any advantage to be gained by it, especially when the ground is steep, as mentioned in the second part of the question. The object of making a surface plan is to reduce every feature on the surface to its relative position on one horizontal plane, on which the underground surveys can be plotted, these also being reduced to the horizontal. Our competitor is not correct when he recommends that in marking out an underground survey on the surface reductions must be made for inclination if the ground be steep. On the contrary, additions must be made for inclination. If the horizontal length of a line underground be 100 yards, and this has to be marked out on the surface the inclination of which, in the direction of the line to be marked out, is, say, 10 degrees, the 100 yards must be divided by the cosine of 10 degrees, giving us a result of more than 100 yards, seeing that the cosine of 10 degrees is less than unity. Or, roughly, we may square the number of degrees, add 50 per cent., and divide by 100, to give the amount of length to be added to the 100 yards. In this case the actual length to be marked out on the slope would be $101\frac{1}{2}$ yards, to correspond to the horizontal length of 100 yards measured underground. But, as we have said before, granted that we have a correct surface plan, we see no benefit to be gained by marking out an underground survey on the surface.—C.C.M.]

Ventilation.

Q. 11.—*Two pits close together are to be sunk to a depth of 250 fathoms. Describe the plant and arrangements you would adopt for their ventilation whilst sinking.*

A.—The ventilation of sinking pits rarely presents any serious difficulty. Various methods of ventilation are employed, these chiefly depending upon the existing circumstances, but whatever method is employed it is absolutely essential that ample ventilating power should be provided, so that the smoke from the shot-firing operations will be quickly cleared away.

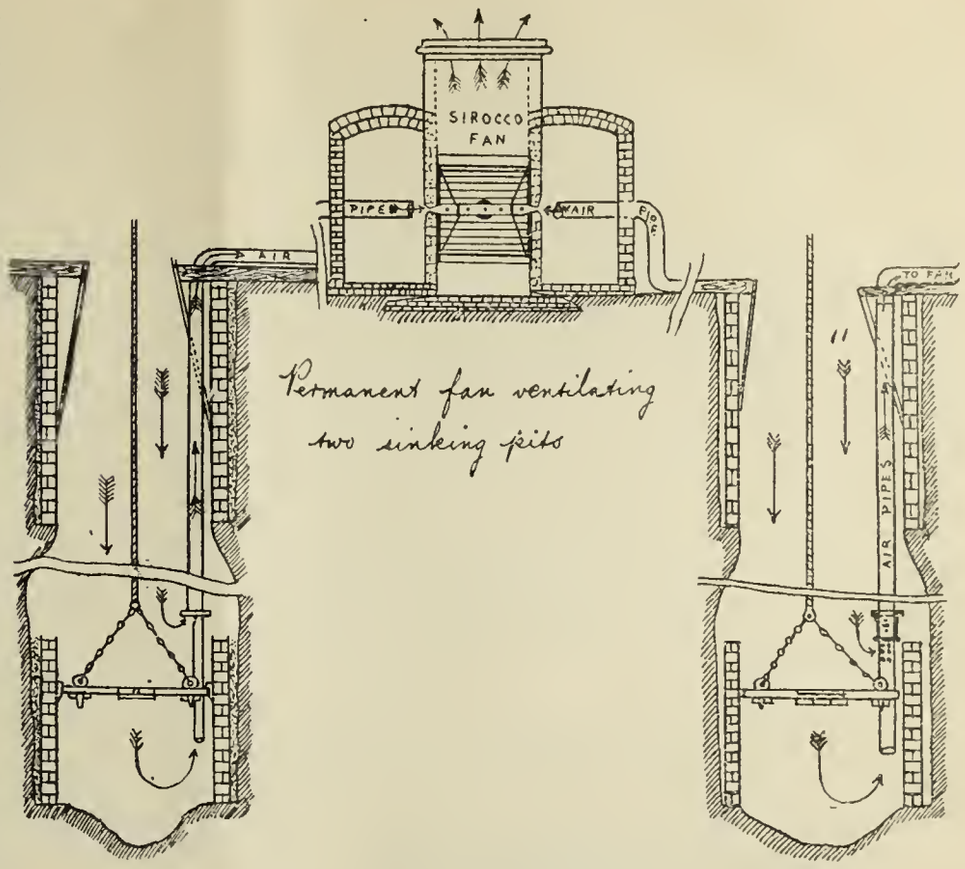
For the efficient ventilation of two sinking pits I should endeavour to ventilate both by the same fan. This could be done as shown in sketch, the fan installed being a double-inlet Sirocco. It can be installed as a permanent fan with as much ease as a temporary fan of any other make which is used for sinking purposes. I would recommend this fan owing to its general suitability, small cost of erection, and small foundations and size of buildings to house the fan.

This fan as shown exhausts the air from the sinking pits, each shaft being separately ventilated, having a separate line of air-pipes in each shaft. The air pipes would be of light galvanised iron, the size being such as required the diameter being generally from 16 to 24 inches diameter. The pipes are usually 9 feet in length, and are attached to each other by means of the ears or lugs riveted on each pipe, through which strong bolts are passed. The air-pipes are either fixed by spiked iron collars to the sides of the shaft, or to buntons fixed across the shaft and let into the brickwork. The fan may be driven by belting from a small steam engine, but preferably by a direct-coupled motor. Whilst the sinking is proceeding the permanent housing for the fan may be built, the air pipes being carried through the brickwork as shown. During bricking or walling operations the air pipes must be continued past the scaffold so that the bottom of the shaft may be adequately ventilated. If a grid scaffold is in use no special arrangement is necessary, but with the ordinary wooden type of scaffold the ventilation is sometimes choked to a certain extent owing to the small amount of space left between the scaffold and the sides of the shaft. This difficulty is overcome by adopting the arrange-

ments shown in the sketch. In one the continuation is made by air pipes of less sectional area, the joint being such that a sufficient quantity of air is supplied to those engaged in walling operations, whilst at the same time enough fresh air passes down the pipes below the scaffold to keep the shaft bottom clear of gas. In the other shaft there is shown a somewhat different arrangement. In this case the pipe immediately above the scaffold is perforated by several small holes, say of ½ to 1 inch diameter, over which a sliding shutter may be placed in such a way as to completely close the holes, and thus prevent the air from escaping. During walling operations the sliding shutter is raised so that a current of fresh air is allowed to sweep the top of the scaffold, the shaft bottom being kept clear by the current of air passing directly down to the bottom of the pipes. If sinking is being carried forward, the sliding shutter is lowered over the holes, thus allowing the whole of the air current to pass down to the bottom of the shaft.

It must be understood that these arrangements can be carried out by either a force or exhaust fan, but I give preference to the latter method since the quantity of air allowed to sweep the scaffold can be regulated by means of the sliding shutter. In sketch the exhaust method is shown, the fan used being the double inlet Sirocco.

It is just as easy to apply the forcing method of ventilation, a different arrangement being, however, required at the surface. In this method the fan would force the air current down the main air-pipes, these splitting in two directions, a suitable branch pipe being used. Each line of air-pipes would ventilate each shaft in the ordinary way.



Illustrating Question 11.

Although there are many more ways of ventilating two sinking pits placed in close proximity, I think the above method (as sketched) is the easiest and best and the one I should adopt, but, of course, sufficient power must be provided or the ventilation of the sinking pits will suffer. The number and size of pipes will vary owing to the depth of shaft, length of each pipe, and as regards size according to depth of shaft and other existing conditions.

Taking into consideration the depth of the shaft I should have the air-pipes about 24 inches diameter. During shot-firing operations I should either protect the bottom pipe, or more preferably have a wire-armoured hose pipe for the bottom pipe, so that it would not need as frequent renewal as an ordinary pipe.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

F. Hutchinson (*12 marks*).

Methods of Working.

Q. 12.—*Under what physical conditions is the long wall system of working coal most suitable?*

A.—The long wall system of working is suitable for nearly all kinds of seams, except under special circumstances, and is generally advocated wherever possible. The physical conditions naturally depend upon the nature of the seam, and it is often quoted that long wall is more suitable to hard thin seams than soft friable ones, especially those with a very hard roof and floor. Soft seams are, however, worked on the long wall principle with advantage where the amount of small coal made is not a matter of any consequence. As a general rule, this system is well adapted to those seams which require, in the production thereof, a maximum percentage of round coal, for this system is the best to achieve this result, due probably to less undercutting required. A seam of average thickness, with a good roof and floor, freely interspersed with dirt, and lying at practically any angle, is well suited to ordinary long wall. Seams having a good floor, but moderately weak roof, are generally worked by some modification of long wall. It enables seams to be worked which would otherwise have to be left alone. For instance, seams varying from 1 to 2½ feet, with a hard rock roof, would be well nigh impossible to work by any other system, as the cost of upkeep would be very large.

The direction in which the face has to be advanced is an important item, being dependent upon the hardness or softness of the seam, cleavage of the coal, and the thickness of cover. In every case the greatest object to be achieved is the production of the greatest possible output in the best marketable condition, with all due regard to economy and efficiency, and to the safety of the workmen. A soft seam should be advanced as rapidly as possible, with the full complement of men employed, otherwise difficulties will arise. On the other hand, in the case of a hard seam, full advantage should be taken of the roof pressure, and so assist the getting of the coal by advancing the face gradually.

The exceptions, in my opinion, to the adoption of long wall working are: (1) Damage to surface buildings or railways. This is probably the greatest disadvantage of the long wall system, especially where the seam is in close proximity to the surface.

(2) Seams liable to gob-fires. Where a gob-fire is apt to occur in long wall working it becomes a very difficult matter to isolate it without sealing off a whole district.

(3) Very thick seams with little or no packing material are very unsuitable to long wall working, on account of the damage liable to be done on the surface due to subsidence.

Long wall working may, therefore, be adopted under a variety of conditions, and the advantage of reducing the percentage of small coal and yielding a larger percentage of round coal is of vital importance in the working of such seams where small coal is comparatively valueless. Probably the coal produced in the working of the seam has to be conveyed long distances by railways or by shipment; hence, the necessity of obtaining large strong lumps for convenience in transportation. House and steam coal varieties of seams are worked long wall exclusively for this reason, whilst, on the other hand, seams of a gas or coking variety, where small coal is of an equal value to round coal, are generally worked by pillar and stall.

Undoubtedly, it is the method par excellence for the introduction of cutting machinery, and as the winning of coal increases in depth long wall working will become the general method.

Wherever packing material is easily obtainable, or, possibly, unavoidably present, it may generally be said that long wall is readily adapted thereto. Refuse for packing purposes is an absolute necessity in this system to build strong packs as the face advances, to support the drawing roads, and, if necessary, to stow up any old or disused road. If the excavation produced by the extraction of the coal is not properly packed to support the roof and allow it to gradually sink down, great expense will be involved in keeping the roadways open. Thin seams, generally, have this refuse on the spot, due to the unavoidable presence of dirt bands, underclays, and the necessity of ripping down the roof to provide the necessary height.

Another feature which makes the long wall system more prominent is the improved system of ventilation it affords, this being evidenced in a greater degree if the line of face is kept fairly straight. When the conditions are anything like favourable for its adoption, long wall is unparalleled as regards safety and economy. In many cases, after the coal has been "holed" either by hand or machine, full advantage is taken of the roof pressure, thereby reducing blasting operations somewhat, which tends to suggest a two-fold advantage, inasmuch as safety is embraced with economy. By this system of working we can curtail ripping expenditure better than in the pillar and stall system, seeing that we require fewer roads to be kept open, and all unimportant roads are cut off as soon as practicable in order to reduce, in many cases, hauling and way-drawing expenses.

Fred J. Aston, 21, Cooper's Lane, Haydock.

F. Hutchinson, W. Heys, W. T. Hughes (*12 marks each*). W. S. Hilton (*8 marks*).

RATE OF BURNING OF FUSE.

In Technical Paper 6 of the U.S. Bureau of Mines, Walter O. Snelling and Willard C. Cope discuss the Rate of Burning of Fuse as influenced by temperature and pressure. In presenting the practical conclusions arrived at as a result of a series of tests the Authors say:—

It is important that time fuse should have a uniform rate of burning, and in almost all blasting operations the fuse that is used is assumed to burn in a regular and uniform manner. When fuse has been subjected to such conditions as produce acceleration or retardation in its rate of burning it becomes dangerous. Acceleration of the rate of burning increases the liability of a shot going off before the miner has left the face; retardation increases the chance of the flame in the fuse progressing so slowly that the miner will be injured by a delayed shot when he returns to the working face. All conditions that bring about any marked change in the rate of burning of fuse are dangerous, and from a study of the list of accidents in mines and quarries each year injury and loss of life are seemingly often brought about by such codnitions.

Under ordinary conditions nearly all types of fuse show great uniformity in their rate of burning. Practically all types of fuse examined in connection with the preparation of this report had a total variation in their rate of burning under normal conditions of less than 20 per cent. and all would have been passed under the allowance of "no variation greater than 10 per cent. above or 10 per cent. below the average rate of burning."

Under the influence of pressure practically all types of fuse are subject to wide variation in their rate of burning. Such pressure as can readily be produced by the confinement of the gases evolved by the burning fuse itself is sufficient to increase the normal rate of burning from 92·5 seconds per metre (28·2 seconds per foot) to 21 seconds per metre (6·4 seconds per foot). Thus, even confinement will cause fuse to burn from three to four times as rapidly as its normal rate. In experiments made with fuse confined by stemming of various kinds wide variations in the rate of burning were noted, and whenever lengths of fuse are confined by stemming or other materials impervious to gas, a sufficient length of the fuse should be used to allow for the increased rate of burning due to the pressure produced by the evolved gases.

High temperature causes a marked retardation in the rate of burning of fuse, and storage for even a short period of time near boilers, or wherever the temperature may be high, is sufficient either to cause "missfires," or to retard the rate of burning of the fuse so much as to greatly increase the liability to "holdbacks," delayed shots, &c. It is probable that many of the difficulties that are sometimes encountered in regard to fuse burning too slowly and causing delayed shots are due, in part at least, to such fuse having been kept in too warm a place. Fuse that is not intended for use in wet places (cotton fuse, &c.) does not suffer marked change in its normal rate of burning by reason of the effect of high temperatures, whereas the more completely waterproofed types of fuse show increasingly great effects from heat. Even exposure to comparatively low temperatures for considerable lengths of time causes marked retardation in the rate of burning of such fuse, and exposure to a fairly high temperature for even a short length of time may cause certain types of fuse to burn from three to five times as slowly as their usual rate. To insure the best results, fuse should always be protected from extremes of temperature.

Climatic conditions affect to a considerable extent the rate of burning of the less waterproof types of fuse. Damp fuse burns more slowly than normal fuse, and fuse that has been wet and then thoroughly dried tends to burn at a rather slow rate, and may even cause delayed shots by smouldering for a considerable time. Fuse containing several wrappings of tape saturated with tar or asphalt resists moisture to a considerable extent, and may be used for firing shots under water, provided the fuse is not allowed to remain too long a time in contact with water before the shot is fired.

It is, of course, evident that when these waterproof types of fuse do become wet, whether through storage for a long time in a damp place or through exposure to water after the protecting layers of asphalt or gutta-percha are mechanically abraded or injured in any other way, they are more difficult to dry out than are other types of fuse, and are more liable to burn at a rate slower than the normal rate.

Fuse that has been subjected to actual mechanical injury, particularly to hammering or pounding or the blows of falling rock, &c., has a greatly increased rate of burning, and sometimes burns so rapidly as to be almost instantaneous in its action. The mere bending, coiling, and twisting of fuse, such as would be brought about by forcibly placing within a bore-hole a length of fuse considerably greater than the depth of the bore-hole, does not produce any marked change in the rate of burning, but pounding or direct abrasion of fuse greatly increases that rate. Fuse that has been injured by severe abrasion or by too great pressure from any cause should not be used in any work where adjustment of the rate of burning is desired.

As a final summary it may be stated that ordinary fuse may under some conditions burn as fast as 3 seconds per metre (1 second per foot), and under other conditions it may burn as slowly as 745 seconds per metre (227 seconds per foot). The former rate is more than 200 times as fast as the latter, and each is widely removed from the normal rate of burning of similar brands of fuse. Hence, the condition and past history of any roll of fuso is an important matter, and in mining and blasting operations the safety of the miner demands that only fuse that has been carefully stored and kept from unfavourable conditions shall be used.

Explosion at Gilfach.

A fatal explosion took place at the Trane pit at Gilfach Goch, in the Ely Valley, an area which is being developed by the well-known Cambrian Combine, who also own the whole of the pits in the Mid-Rhondda district. Three badly mutilated bodies were recovered, and three men were severely injured, and are slightly burned. The men were sinking a new shaft at the time of the explosion. The top of the shaft was greatly damaged, and huge volumes of smoke arose which could be seen for miles around.

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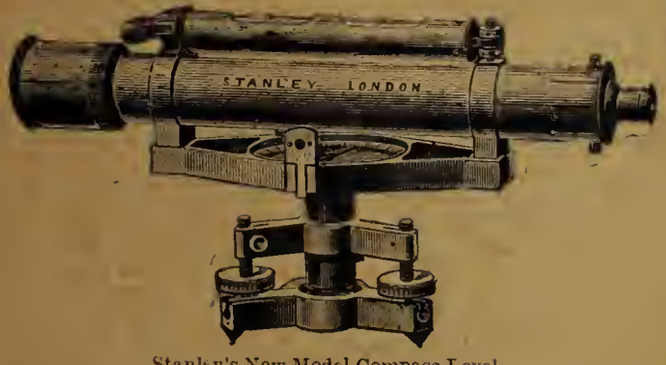

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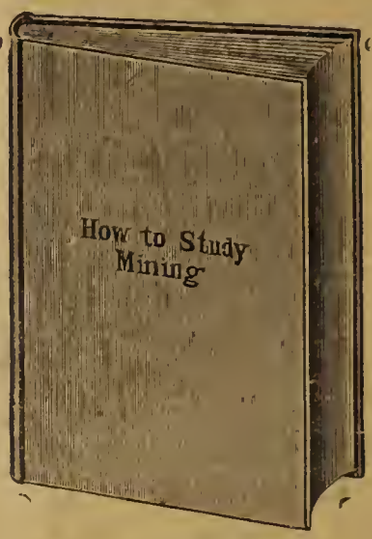

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VOL. XXII.—No. 20.] SATURDAY, MAY 11, 1912. [PRICE 3d.

NEWS AND NOTES.

To Assist the Lord of the Manor.

Mr. Vickers Wade, a Pudsey auctioneer, who has had control over the rights of the manor of Pudsey, says he hopes before long that minerals will be realised, and the funds invested for the benefit of Mr. Joshua Illingworth, the lord of the manor, who is now in Bradford workhouse. Coal, it will be remembered, was found on the land during the recent coal strike.

Excursions Popular.

The Mining Institute of Scotland have agreed to a proposal to hold an excursion annually to some attractive holiday spot in the East or West. The idea of blending occasional pleasure with technical papers and discussions appears to be getting quite a popular one now, for other kindred organisations, the National Association of Colliery Managers and the Association of Mining Electrical Engineers, propose joining in an outing together this summer.

South Yorkshire Developments.

One of the latest developments of the new South Yorkshire coalfield is at Rossington, where a company has been formed by the combination of the Sheepbridge Coal and Iron Company and Messrs. John Brown and Co., with a capital of £600,000. Preparations are being pushed forward for an early start with the new colliery, and the first sod will be cut almost immediately. Sinkers' huts are in preparation, and the sinking plant is being delivered. A branch line of the Great Northern Railway Company was completed some time ago, and the colliery company are now laying down sidings to the site, which is about a mile and a half from the main line. Between two and three hundred men will be employed in the early stages of the sinking. It is expected that the Barnsley seam will be found at a depth of from 850 to 880 yards, and it is proposed to equip the colliery with plant capable of raising from 5,000 to 6,000 tons a day.

Iron and Steel Institute.

At the annual meeting this week the following papers were promised: (1) "Notes on the Solubility of Cementite in Hardenite," by Dr. J. O. Arnold and L. Aitchison (Sheffield). (2) "On the Chemical and Mechanical Relations of Iron, Vanadium, and Carbon," by Dr. J. O. Arnold (Sheffield) and Professor A. A. Read (Cardiff). (3) "Notes on a Bloom of Roman Iron from Corstopitum (Corbridge)," by Sir Hugh Bell, Bart. (Middlesbrough). (4) "The Influence of Carbon on Corrosion," by C. Chappell (Sheffield). (5) "The Manufacture and Treatment of Steel for Guns," by General L. Cubillo (Valladolid, Spain). (6) "The Corrosion of Nickel, Chromium, and Nickel-Chromium Steels," by Dr. J. N. Friend, J. Lloyd Bentley, and W. West (Darlington). (7) "On the Mechanism of Corrosion," by Dr. J. N. Friend, W. West, and J. Lloyd Bentley (Darlington). (8) "Sinhalese Iron and Steel of Ancient Origin," by Sir Robert A. Hadfield, F.R.S. (Sheffield). (9) "Modern Rolling-Mill Practice," by J. W. Hall (Birmingham). (10) "The Influence of Heat on Hardened Tool Steels," by E. G. Herbert (Manchester). (11) "Improvements in Electric Steel Furnaces and their Application in the Manufacture of Steel," by Dr. H. Nathusius (Friedenshütte, Upper Silesia). (12) "A New Process for the Investigation of Fractured Surfaces of Steel," by F. Rogers (Sheffield). (13) "The Welding Up of Blow-holes and Cavities in Steel Ingots," by Dr J. E. Stead, F.R.S. (Middlesbrough). (14) "Note on some Remains of Early Iron Manufacture in Staffordshire," by Professor T. Turner (Birmingham).

Sub-Inspector's Appointment.

Mr. Tom Gawthorpe, an official at the Hickleton Main Colliery, who is one of the three candidates appointed to the post of H.M. Sub-Inspector of Mines, taking up his residence in Sheffield, has made noteworthy progress in the mining world. He is only 31 years of age. He commenced work at Hickleton when he was 14, and has since gained a wide experience in the working of a mine. He early began to make a deep study of coal mining, and after finishing his shift, regularly studied, attending at the local mining classes. He obtained his second-class manager's certificate at a comparatively early age, and was appointed a deputy, which position he held for six years. Fifteen months ago he obtained his first class certificate, and was appointed afternoon overman, or under-manager, which position he now vacates for his new appointment. Mr. Gawthorpe is stated to have been the youngest candidate who sat at the examination for the inspectorships, and to have obtained the highest number of marks in the country. He is a native of Wombwell, and secured a three years' course of tuition at the Sheffield mining classes. He has a brother who is under-manager at the Brodsworth Colliery. Mr. Gawthorpe's district as Sub-Inspector includes the Sheffield side beyond the Don area of Yorkshire and the Derbyshire area.

Mine Gas Testing.

For various reasons much greater attention has recently been paid to the question of mine gas testing, and in this connection it has been found that a considerable difference of opinion exists as to the effect of increased barometric pressure on the cap given by a certain percentage of fire-damp. Seeing that very shortly practically all firemen and deputies must pass an examination in gas testing, it would seem to be exceedingly desirable that such tests should be made under conditions of barometric pressure approximating to those which hold good in mines, especially as many modern pits are of a very great depth. If any noticeable alteration in the cap does take place as the barometric pressure varies, the need for some apparatus by means of which the firemen and deputies may experiment under conditions approximating to pit conditions becomes very urgent, particularly in the case of those employed in deep mines. Such an apparatus should be efficient, inexpensive, and simple in construction, so as to be easily understood by the average fireman or deputy. An apparatus for this purpose has recently been designed by Mr. James Eagles (Principal of the Doncaster Technical School), and Mr. George A. Lodge (Lecturer in Mining, Gas-Testing, &c., at Doncaster and Batley technical schools, and Huddersfield Technical College), which would seem to fulfil the conditions laid down, and by means of which some very interesting observations have already been made. It consists of a pressure-tight metal chamber having the necessary taps and valves for the admission and regulation of air and gas, a window for observation purposes, an arrangement for altering the height of the lamp flame whilst under pressure, an agitator for mixing the air and gas, and a means of measuring the pressure. Suitable arrangements have also been provided for quickly and effectually emptying the chamber of its gaseous contents after a test has been made. A pressure of 3 inches of mercury over and above atmospheric pressure —equivalent to the pressure obtaining in a pit 900 yards deep —may easily be obtained and kept up during each test. The apparatus is simple and portable, and should form a useful addition to the equipment of all up-to-date mining schools. It has been provisionally protected.

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No. 10.—Linear and Angular Motion.

The following further examples are presented to enable the reader to acquaint himself with the analogous relations in linear and angular motions summarised in the last issue of this Journal:

Ex.—A flywheel running at 80 revolutions per minute is brought to rest in ½ minute, the angular retardation being uniform. Find the angle turned through in radians and in degrees.

80 revolutions per minute $= \frac{80}{60}$ revolutions per second $= \frac{4}{3}$, and 1 revolution $= 2\pi$ radians.

$\therefore$ Angular velocity $\omega = 2\pi \times \frac{4}{3}$ radians per second.

The flywheel is uniformly retarded until all motion is destroyed.

At the beginning the velocity $= \omega = 2\pi \times \frac{4}{3}$.

At the end the velocity $= 0$.

$$\therefore \text{Average velocity} = \frac{\omega}{2} = \frac{4}{3} \times \pi.$$

The angular displacement $\theta = \frac{1}{2}\omega t = \frac{1}{2} \times \frac{4}{3} \times 2\pi \times 30$.

$\therefore$ Angle turned through in radians $= 125{\cdot}6$.

To find the angle in degrees we know that

$\frac{d}{180} = \frac{\theta}{\pi}$, where d = angle in degrees.

$$\therefore d = \frac{180}{\pi} \times \theta = \frac{180}{3{\cdot}1416} \times 125{\cdot}6.$$

$\therefore d = 7200°$.

Ex.—A body moving at 60 feet per second is brought to rest by a uniform retardation in a distance of 5 yards. Find the retardation and the time occupied.

Let a = the retardation.

Then $v^2 = 2al$,

$$\text{and } a = \frac{v^2}{2l} = \frac{60 \times 60}{2 \times 15} = 120 \text{ feet per second}^2.$$

$$\text{Since } v = at \quad \therefore t = \frac{v}{a} = \frac{60}{120} = {\cdot}5 \text{ second.}$$

Ex.—A body rotating at 50 radians per second is brought to rest by a uniform angular retardation in the space of 1½ turns. Find the retardation and the time occupied.

Here $\omega^2 = 2a\theta$.

That is the square of the angular velocity = twice the angular acceleration multiplied by the angular displacement.

The angular displacement $\theta = 1\frac{1}{2} \times 2\pi$.

$$\therefore a = \frac{\omega^2}{2\theta} = \frac{50 \times 50}{2 \times 1\frac{1}{2} \times 2\pi} = \frac{50 \times 50}{3 \times 2 \times 3{\cdot}1416}.$$

$\therefore a = 132{\cdot}6$ radians per second^2.

$$\text{Since } \omega = at. \quad \therefore t = \frac{\omega}{a} = \frac{50}{132{\cdot}6} = {\cdot}37 \text{ second.}$$

Ex.—A car weighing 3 tons is moving at the rate of 15 miles per hour. Find its velocity in feet per second. Its momentum in pound seconds, and its kinetic energy in ft.-lb.

Velocity.—A velocity of 15 miles per hour

$$= \frac{15 \times 5280}{60 \times 60} \text{ feet per second} = 22 \text{ feet per second.}$$

Momentum.—Momentum in pound-seconds = mass in sluggs × velocity in feet per second

$$= \frac{w}{g} \times v = \frac{3 \times 2240}{32{\cdot}2} \times 22 = 4590 \text{ lb.-seconds.}$$

Kinetic Energy:—

$$KE = \frac{1}{2} \frac{w}{g} v^2 = \frac{3 \times 2240 \times 22 \times 22}{2 \times 32{\cdot}2} = 50{,}490 \text{ ft.-lb.}$$

Ex.—A flywheel weighing 3 tons, and having a radius of gyration k of 4 feet, is turning at the rate of 150 revolutions per minute. Find its angular velocity in radians per second, its angular momentum in lb.-ft. seconds, and its KE of rotation in ft.-lb.

Angular Velocity:—

Angular velocity $= 2\pi N = 2\pi \times \frac{150}{60} = 3{\cdot}1416 \times 5$.

$\therefore \omega = 15{\cdot}71$ radians per second.

Angular Momentum:—

Angular momentum = Inertia × angular velocity.

$$\therefore \text{Angular momentum} = I\omega = mk^2\omega = \frac{w}{g} k^2 \omega.$$

$$= \frac{3 \times 2240}{32{\cdot}2} \times 4 \times 4 \times 15{\cdot}71 = 5244 \text{ lb.-ft.-seconds.}$$

Kinetic Energy of Rotation:—

$$KE = \frac{I\omega^2}{2} = \frac{1}{2} (I\omega) \times \omega.$$

$$= \frac{1}{2} \times 5244 \times 15{\cdot}71 = 41{,}200 \text{ ft.-lb.}$$

Ex.—A force of 200lb. acts on a free mass of 3,220lb. Find the acceleration.

Here $F = ma$.

$$\therefore a = \frac{F}{m} = \frac{F \times g}{w} = \frac{200 \times 32{\cdot}2}{3220} = 2 \text{ feet per second}^2.$$

Ex.—A torque of 200 pound-ft. acts on a flywheel and shaft having a mass of 3,220lb. and a radius of gyration of 3 feet. Find the angular acceleration, friction being neglected.

Here torque = inertia × angular acceleration, or $T = Ia$.

$$\therefore a = \frac{T}{I} = \frac{T}{mk^2} = \frac{Tg}{wk^2} = \frac{200 \times 32{\cdot}2}{3220 \times 9} = {\cdot}2 \text{ radian per second}^2.$$

Ex.—A car weighing 2½ tons starts from rest under the action of a pull of 300lb. Find the momentum and the velocity after a lapse of 6 seconds.

$$\text{Here acceleration} = \frac{\text{Force}}{\text{Mass}} = \frac{gF}{w} = \frac{32{\cdot}2 \times 300}{2{\cdot}5 \times 2240}.$$

The velocity of car after 6 seconds $= v = at$

$$= \frac{32{\cdot}2 \times 300}{2{\cdot}5 \times 2240} \times 6 = 10{\cdot}35 \text{ feet per second}$$

$$\text{and momentum} = \frac{2\frac{1}{2} \times 2240 \times 10{\cdot}35}{32{\cdot}2} = 1{,}800\text{lb.-second.}$$

Ex.—A grindstone weighing 1,200lb., and having a radius of gyration of 1·4 feet starts from rest under a uniform torque of 50lb.-ft. Find the angular momentum and the angular velocity at the end of 10 seconds.

$$\text{Angular acceleration} = \frac{\text{Torque}}{\text{Inertia}}.$$

$$\therefore a = \frac{T}{I} = \frac{T}{mk^2} = \frac{Tg}{wk^2} = \frac{50 \times 32{\cdot}2}{1200 \times 1{\cdot}4 \times 1{\cdot}4}.$$

Angular velocity:—

$$\omega = at = \frac{50 \times 32{\cdot}2}{1200 \times 1{\cdot}4 \times 1{\cdot}4} \times 10 = 6{\cdot}84 \text{ radians per second.}$$

Angular momentum $= I \times \omega = mk^2\omega$.

$$= \frac{w}{g} \times k^2\omega = \frac{1200}{32{\cdot}2} \times 1{\cdot}4 \times 1{\cdot}4 \times 6{\cdot}84 = 500 \text{ lb.-ft.-seconds.}$$

Ex.—A train weighing 200 tons and moving at 40 miles per hour is brought to rest by the action of the brakes in 350 yards. Supposing the force to be constant, find its magnitude and the time taken in stopping the train.

Here the work expended in stopping the train = kinetic energy in train, *i.e.*:—

$$F \times l = \frac{w}{g} \frac{v^2}{2} \qquad v = \frac{40 \times 5280}{60 \times 60} = 58\frac{2}{3} \text{ feet per second.}$$

$$\therefore F = \frac{w}{g} \times \frac{v^2}{2l} = \frac{200 \times 2240}{32{\cdot}2} \times \frac{58\frac{2}{3} \times 58\frac{2}{3}}{2 \times 350 \times 3}.$$

$$\therefore F = 22{,}800\text{lb.}$$

$$\text{Time taken in stopping} = \frac{\text{Displacement}}{\text{Average velocity}} = \frac{l}{\frac{1}{2}v} = \frac{2l}{v}$$

$$= \frac{350 \times 3 \times 2}{58\frac{2}{3}} = 35{\cdot}8 \text{ seconds.}$$

Ex.—A grindstone having a moment of inertia of 55 slugg feet², and rotating at 8 radians per second, is brought to rest by a constant frictional torque after making 50 turns. Find the torque and the time occupied.

The moment of inertia

$$I = \frac{w}{g} k^2 \text{ slugg feet}^2 = 55 \text{ slugg feet}^2.$$

Here work done in stopping rotation = energy of rotation.

$\therefore$ torque × angular displacement = ½ inertia × the square of the angular velocity.

$$\text{Or, } T \times \theta = \frac{I\omega^2}{2}.$$

$$\therefore T = \frac{I\omega^2}{2\theta} = \frac{55 \times 8 \times 8}{2 \times 50 \times 2\pi} = 5{\cdot}602\text{lb.-ft.}$$

$$\text{Time taken in stopping} = \frac{\text{Angular displacement}}{\text{Average angular velocity}}$$

$$= \frac{\theta}{\frac{1}{2}\omega} = \frac{2\theta}{\omega} = \frac{2 \times 50 \times 2\pi}{8} = 78{\cdot}54 \text{ seconds.}$$

Ex.—A force of 100lb. acts on a carriage which has a velocity of 10 miles per hour. Find the power exerted.

Power = force × velocity

$$= 100 \times \frac{10 \times 5280}{60 \times 60} = 1466 \text{ ft.-lb. per second.}$$

Ex.—A torque of 250lb.-ft. acts on a shaft which runs at 120 revolutions per minute. Find the power exerted.

Power = torque × angular velocity

$$= 250 \times \frac{120 \times 2\pi}{60} = 3142 \text{ ft.-lb. per second.}$$

SURVEYING.

By COLLIERY SURVEYOR.

The optical square was described in No. 15, Vol. 21. To examine for adjustment, proceed as follows: Place two poles a good distance apart, say 80 to 100 yards. Fix an intermediate short pole or tripod head midway, and in direct line with the two poles. From this point range out another pole to form an ∠ of 90 with the line of the two poles. Move this pole until, when sighting to one of the two poles in the straight line from the intermediate point, the offset or rt. ∠ pole appears in the optical square to be coincident. Turn the instrument right over, and sight to the other pole, and if the offset pole is again coincident the optical square is in perfect adjustment. If it is not coincident, the adjusting key must be used to correct for half the difference. The observation may need repeating several times until, whichever pole is sighted along the line from the intermediate point, the offset pole at 90° appears coincident. It is obvious that no reliance can be placed upon the use of the optical square until its adjustment has been attended to and made perfect.

The Box Sextant: its adjustment. The most usual adjustment in this instrument is for parallelism of the two mirrors at zero reading on the graduated arc. This can be done by observation of the sun when the latter is not at too high an angle. Another plan is to sight to some sharply defined object a good distance away, say three or four furlongs. If the object sighted is seen clear and continuous across the silvered and unsilvered portions of the horizon glass the sextant is in adjustment. If not, the horizon glass must be adjusted by means of the adjusting key which is fitted with the instrument. This correction is sometimes called the adjustment to zero of arc, and if the sighting is done to an object at close quarters, say half a chain or a chain distant only, errors due to parallax will prove troublesome, and make the adjustment well nigh impossible.

Examples to be Worked Out.*

Readers working out the appended questions and who desire a test of their ability, should submit their answers to COLLIERY SURVEYOR, care of *The Science and Art of Mining* Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means answers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonies and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to COLLIERY SURVEYOR at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the regular series of articles.

1.—*The area of the surface of water in a reservoir is 116,850 square feet. If the surface be lowered 5 feet, and thereby reduced in area to 66,200 square feet, find the number of gallons which have been drawn off.*

2.—*In a circle of 3-inch radius, draw two chords, AB, BC, 2·75″, and 1·38″ in length respectively, and the diameter BD. Join AD and CD. Find the numerical values of the angles ADB, BDC,* (a) *by using your protractor;* (b) *by any other method.*

3.—*Plot to any suitable scale the traverse recorded below:—*

No.	*Azimuth.*	*Horizontal Distance.*
1	*90°45′*	*400 feet.*
2	*106°45′*	*850 feet.*
3	*48°22′*	*1147·5 feet.*
4	*0°45′*	*200 feet.*

Find from your plan the azimuth and length of the line from the starting point of the traverse to its end.

4.—*A △ plotted on an Ordnance Survey map on a scale of $\frac{1}{2500}$ has three sides of the following lengths: 6·43″, 5·58″, 4·76″. Calculate the area of the triangle in acres, roods, and poles. Check by way of a plan, and a single measurement on the plan.*

NEW SOUTH WALES COAL INDUSTRY.

The New South Wales coal output in 1911 amounted to 8,691,604 tons, valued at £3,167,165, an increase of 518,096 tons and £157,509 in value, compared with 1910. To oversea ports 2,498,304 tons of coal were shipped, and Australasian ports received 2,525,776 tons, the total increase of shipments being 333,647 tons. The collieries in the northern district supplied 5,793,646 tons, those of the southern district 2,065,621 tons, whilst the western district product amounted to 831,337 tons. The collieries in the northern district were at work during the whole of the year, except for a few local strikes, whilst in 1910 they were all idle for the first ten or eleven weeks in the year. The southern coal trade was more regular, and was interrupted very little by labour troubles. The output from the western district was considerably less than that of the previous year, in the early part of which the trade was abnormal in consequence of the general strike which then existed in the other districts.

* City and Guilds, Grade I., 1912.

NOTES FROM WALES.

By BRYCHAN.

South Wales Mining Examination—(continued).

In any examination it is very desirable that the candidate should consider carefully the question proposed before attempting an answer. In a written examination he should read each question over at least twice; frequently he will find that the second reading conveys to his mind an entirely different impression to that of the first reading. So also a second deliberate reading of the questions often satisfies a nervous candidate that he is able to cope with what appeared to him a hopeless task during the first reading.

In any case it is never wise to attempt an answer until it is thought the requirements are fully understood. This done, the candidate should confine his answer *strictly to the question proposed.* Going off the track in this respect is a blunder which few examiners are prepared to condone, and no extra credit will be given for information which is not asked for.

Order of Answering the Questions.—If possible, it is better to take these in order, the candidate having paid due regard to the time likely to be required for each question. Another and sometimes better plan is to take the easiest questions first. If compulsory questions are set, these should always be taken first of all, since dealing with other questions until there is no time to answer the compulsory ones means failure in that paper. On the other hand, if the compulsory questions are answered, even though little other work has been dealt with, there is always hope. In any case, the candidate should bear in mind that, although time is always fleeting, it appears to have the knack of doing this at about twice the usual speed during an examination test.

But to come to the South Wales Mining Examination. At the outset it may be stated that here the examiners are nothing if not thorough, and they are as practical as they are thorough. For this reason it is never safe for the candidate to describe a system of working coal which he has not seen or worked at. Awkward questions may later be set him at the oral. If, therefore, a question asks for a description of pillar and stall, the candidate should beware of describing the bord and pillar system of the North Country, unless he hails from that part, or has spent some time there, and is perfectly conversant with that system of working. Similarly, if a description of long wall working is required, he should beware of describing the Nottingham system in preference to the ordinary heading and stall, unless he is better acquainted practically with the former.

In the Mechanical Engineering paper, problems as to sizes of engines required to deal with certain quantities of mineral under given conditions are frequently set, with an addendum requiring the candidate to show details as to calculations. Here again, rule of thumb procedure will not avail, and the smart guesser is at a discount. While required to be eminently practical, the candidate must also show that he has scientific knowledge as the groundwork of his subject. It is brought home to him that he is a poor engineer who lays down any engine at random without having previously worked out all detailed calculations.

It will be noticed that the Arithmetic test is not difficult, and when this paper is placed before him the candidate should be sure he *understands* the question before commencing to answer it. In this subject more failures occur through not realising what is required than from any other source. Make all calculations in the margin to the left-hand side. The work should be neatly done, and methodically arranged, so that the examiner can follow the argument step by step. Straight lines and straight rows of figures look much better than sloping crooked ones, and the answer should stand out prominently. No candidate has the right to expect an examiner to search among a maze of figures for the answer to the problem. Keep the work clean.

The Mathematics of Ventilation are lightly dealt with, but practical problems arising out of the ordinary working of mines are usually set, *e.g.*, the arrangements for ventilation of one or two cross measure headings driving through faulty ground, and for the workings in the seam beyond; the dilution of blowers and removal of accumulations of gas under difficult conditions, &c. Searching questions as to the precise duties of certain officials are frequently set. Here, again, the value of practical experience cannot be exaggerated.

For the candidate who has prepared himself by careful study the paper in Surveying is by no means difficult. A few bearings requiring a tie to the starting point, with direction and length of such tie, are usually among the questions set. Should there be any doubt as to the proper point to start from, in view of the fact that no extra credit is given for going off the paper and completing the line possibly on a piece of attached blotting paper, the lines should be drawn on a small scale approximately by hand as to direction and length, and thus the proper position to start from is fixed. Should $\angle$s of elevation and depression be given, the horizontal or plotting length must be found, and this can only be satisfactorily done by the use of tables. Probably through some oversight, their use in the past at this examination centre has been prohibited, but it is to be sincerely hoped that permission to use the tables will not be withheld in the future. The writer has known a question set in this subject whose value as a test of the skill and ability of the candidate for a 1st Class Certificate, he cannot appreciate. It was required to draw a few lines of certain bearings and lengths without the use of protractor or scale, to show knowledge of angles and lengths. To the writer this would appear to be a case where exactness is at a discount, and the man with a "good eye" is likely to score.

However clever the workman, he cannot show to advantage without tools, and the better the tools the better will be his work. This applies specially in Surveying. The outfit need not necessarily be expensive, but it is a good maxim that the appliances should be of as high a quality as the candidate *can afford to pay for.* He will require as a minimum the following articles: Protractor, Parallel Ruler, Scale, and Drawing Pen. A Compass and Dividers being also frequently useful.

In the paper on Geology, questions as to the sections of seams in the candidate's own locality, with a description of the various qualities of coal in the coalfield, together with a few questions as to definition of geological terms, indicate the trend of the work in this subject. The candidate should be fairly conversant with the solid geology of the coalfield, as there is always a possibility of being asked to take a geological walk over some portion thereof, and to describe in detail the strata passed over.

The C.M.R. Act.—Candidates are prone to treat this subject lightly on the ground that it is chiefly memory work. To a great extent this is so, yet, unless the subject be tackled in a proper manner, it means a great amount of dreary work committing to memory. (1) The student should see that he has the C.M.R. Act *up-to-date.* This means that, besides the C.M.R. Act of 1887 and the special rules of his particular colliery or district, he must be possessed of all the amendments up to the present as well. He must be sure he has the *latest* "Explosives Order," and the *latest* "List of Permitted Explosives." Presuming a thorough preparation in this, as in the other subjects, it only remains for the candidate to write his answers in a *clear* style, *always avoiding* (unless the contrary is desired) *literal repetition in the words of the Act, i.e.*, he should use *his own phraseology*, answer pithily and concisely, avoiding the wearisome "*He shall*," and "*He shall not*," wherever possible. It should be noted that the Act in which candidates are to be examined this month at Cardiff is the one at present in force, *and not the C.M.R. Act, 1911.* This seems somewhat incongruous, inasmuch as a successful candidate will manage a mine under the 1911 Act without having been required to prove his acquaintance with the same. However, it is an ill wind that blows nobody good, and it is fortunate for the student that the nearly obsolete Acts form the basis of the work on this occasion.

To discuss, on the eve of an examination, the mode of preparation for the same would be almost as ill-timed as the closing of the proverbial stable door after the horse has bolted. This may perchance form the theme for a later article, and for the present it is presumed that the training of the candidate has extended assiduously, conscientiously, and systematically over a period of at least twelve months. He should have reached such a state of confidence that he can afford to give his brain a rest for a day or two before the examination. Unless the work has been properly covered prior to that time, no great results can be expected of the candidate who, for instance, has his face

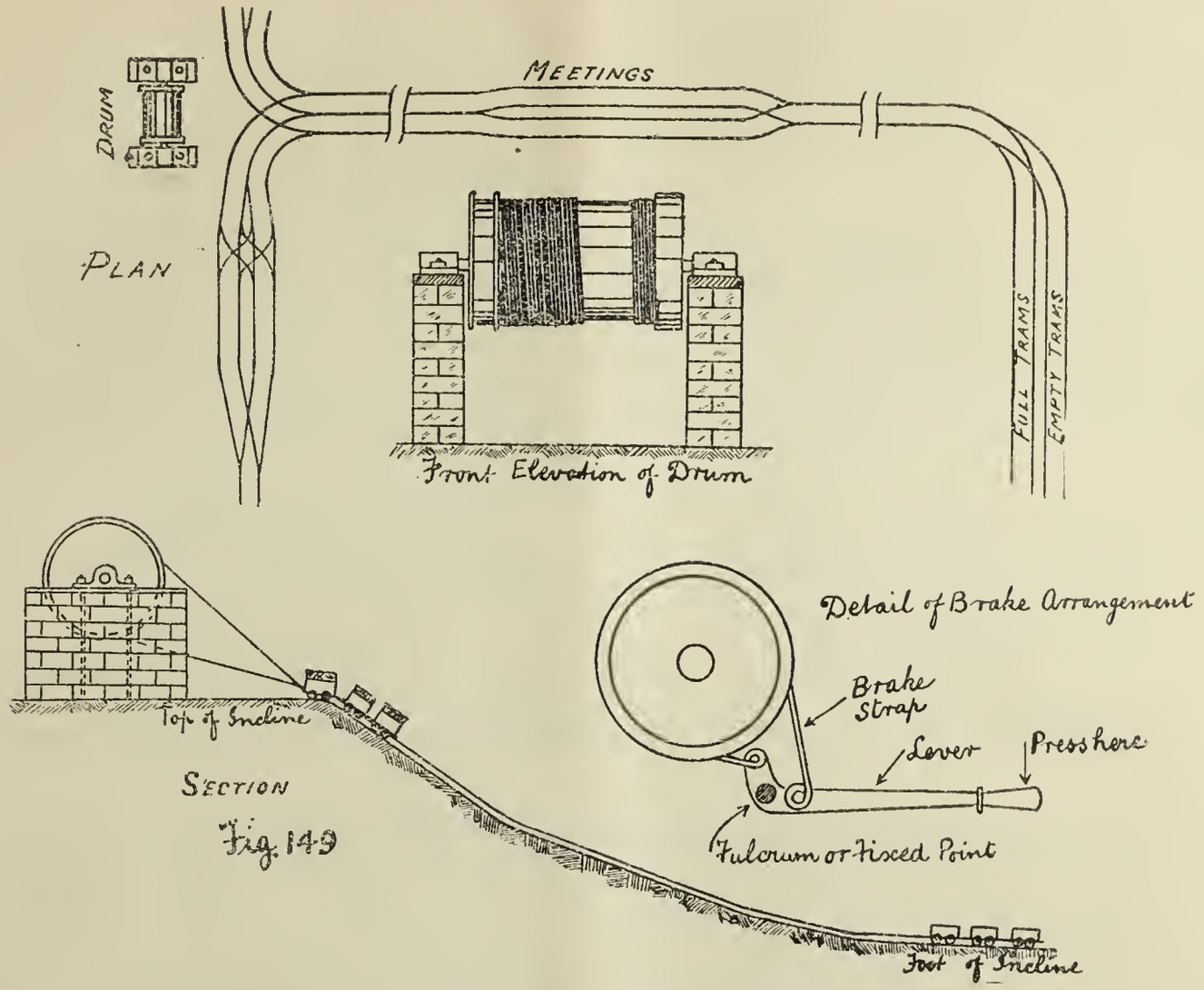


Fig. 149

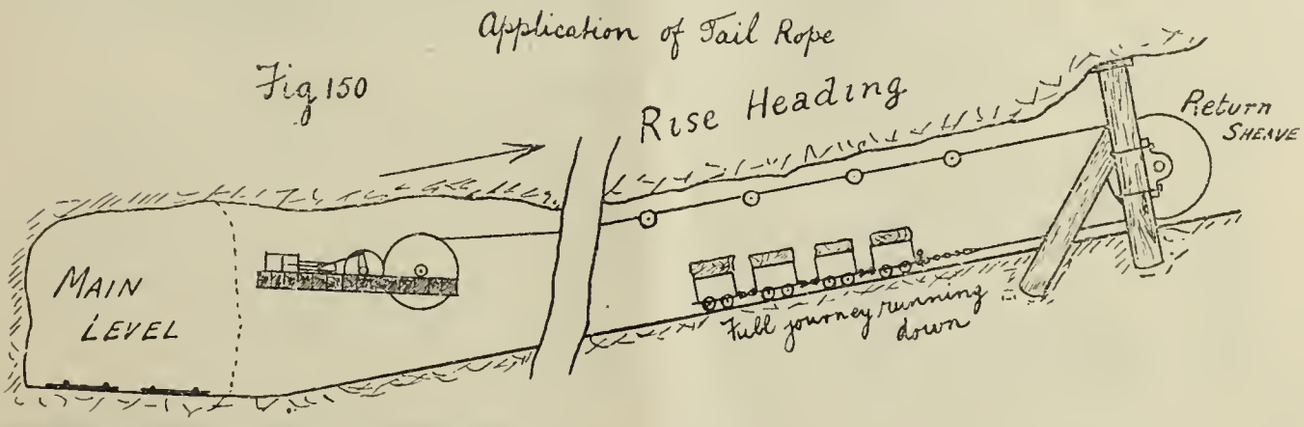


Fig 150

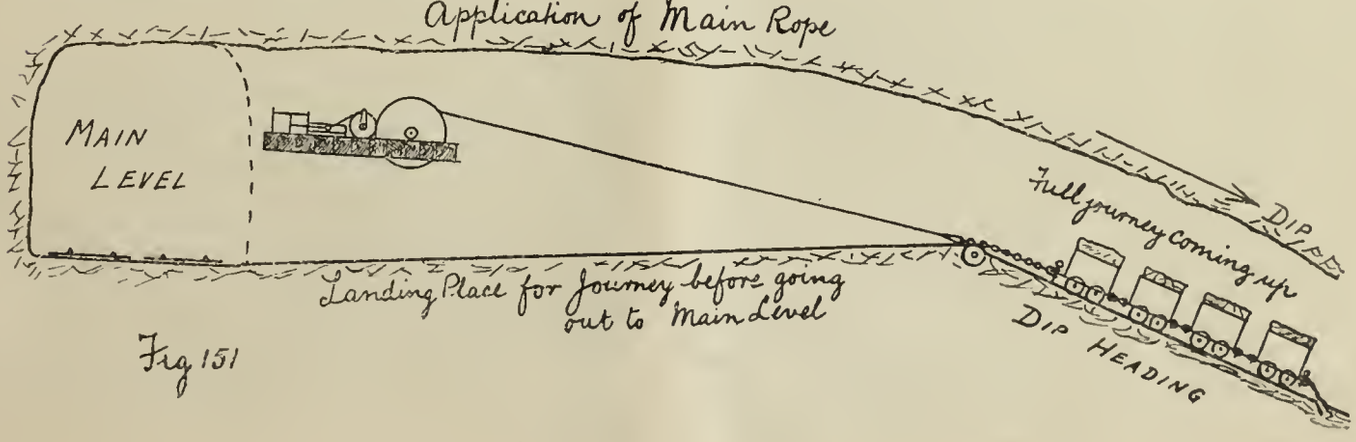


Fig 151

buried in the pages of his "Mines Act," or "Mining Formulæ" up to the moment of entering the examination room.

The value of sketches, diagrams, &c., cannot be over-estimated. These may be good, bad, or indifferent. The ability to draw a neat sketch in the often brief time at one's disposal is a valuable asset, and should be cultivated to the utmost. It increases the chances of success of the student, and saves time and trouble for the examiner.

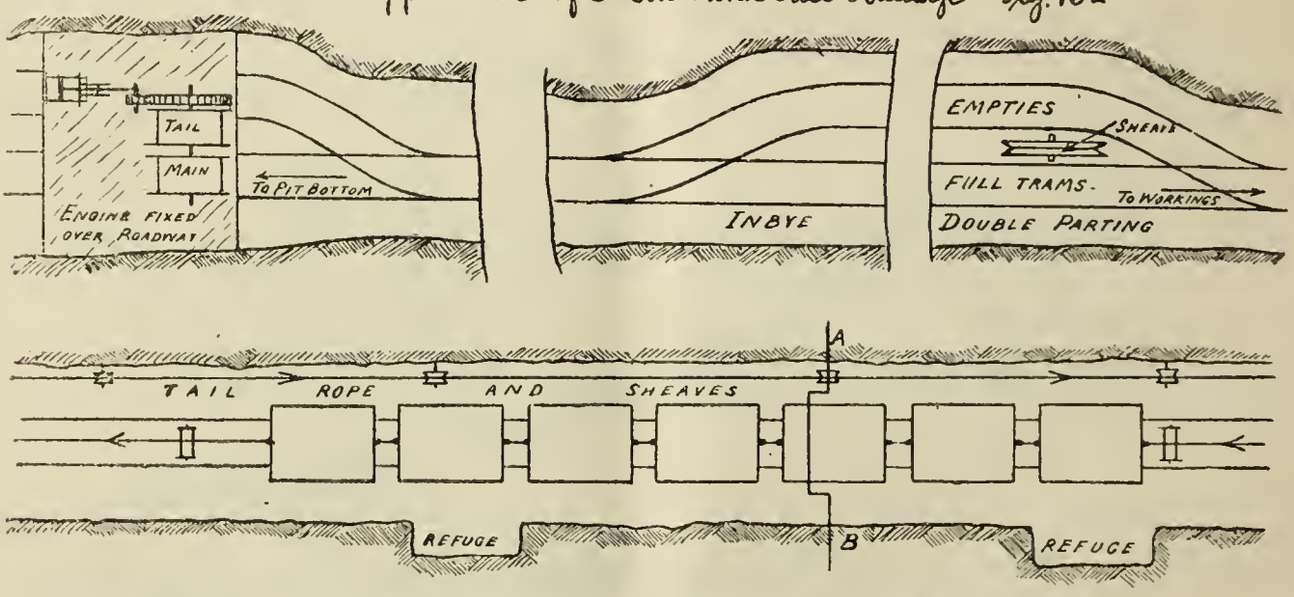
Oral Examination.—Up to the present the oral has not formed an essential part of the South Wales Examination. The candidate may be called before the examiners for several reasons: (*a*) Some point with respect to his official forms and testimonials requires elucidating; (*b*) he may have been rather obscure in his exposition of some problem during his paper work, and he is given an opportunity for explanation; (*c*) he may even be called before them to receive congratulations. It is worthy of note that on this last point the examiners are sufficiently magnanimous, and certainly do not think it *infra dig* to encourage a candidate by offering their congratulations for good work done. To be called before the examiners is considered by some candidates to be a hopeful sign; nay, an almost certain augury of success; while others think quite the opposite. Personally, for reasons given above, the writer attaches no importance to it in either direction. A successful candidate may or may not be called out, and the same applies to an unsuccessful candidate. Speaking from personal experience of the two occasions on which the writer sat at Cardiff, the first occasion for his Second Class Certificate, and afterwards for his First Class Certificate, he was not called out on the first occasion, but was called on the second. In each case he secured his pass. Any number of other cases could be cited. Candidates should not, therefore, become disheartened, nor unduly optimistic, merely upon the matter of being called for an oral interview.

Before bidding them farewell, and wishing them all good luck in the examination room, the writer desires to impress upon candidates that in no respect is the educational value of the Tours and Courses Scholarships of the Glamorgan Education Committee more strongly emphasised than in the training of men for this (to many) all important examination. The fact that a candidate may, either at home or abroad, visit for one or two weeks a group of the best equipped collieries and works, at the same time being given *carte blanche* to see, and obtain information about, all he desires, is sufficient justification for the keen competition that prevails for places on these tours. Mining Engineering (Mechanical and Electrical) is well provided for in a three weeks' course at Cardiff, and for the same period Practical Mine Surveying and Firemen's Courses at Penarth, near Cardiff. In fact, the whole series, so ably arranged and administered by the Director of Mining Instruction for Glamorgan, furnishes incontrovertible proof that, if opportunities are grasped, there is no reason why any South Wales mining student should be called upon to part with more than the minimum £3 for his Home Office Certificates.

HAULAGE.

For description of the figures appended and illustrating the various systems of haulage the reader is referred to pp. 410-411, No. 18, Vol. 22.

Application of Main and Tail Haulage Fig. 152



Plan showing journey or set on Engine plane

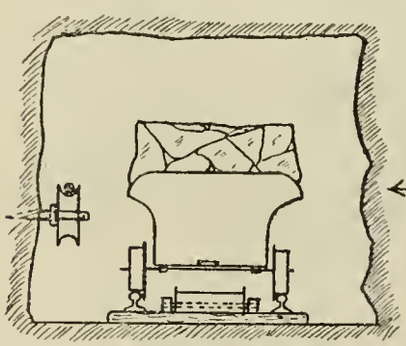


Fig. 152 a

FIFESHIRE MINING DEVELOPMENTS.

According to reports it is likely that there will be some extensive developments in connection with the Fifeshire coal trade. A Dunfermline firm have started boring operations to the west of the village of Comrie, and they hope to tap what is known as the Dunfermline splint seam, but to do this they will have to go to a depth of 300 fathoms. In connection with the new colliery at Blairhall—also near Dunfermline—houses are to be erected for about 1,000 workmen, and it is expected that this district will become one of the most important mining centres in Fifeshire. Screening plant has been installed at the colliery which is owned by the Coltness Iron and Coal Company, and there are two engine-houses, and also duplicate sets of machinery.

VIEWS AND REVIEWS.

An Elementary Text-Book of Metallurgy.—By A. Humboldt Sexton, F.I.C., F.C.S Price, 6s. London: Charles Griffin and Co., Ltd., Exeter Street, Strand.

This manual by Professor Sexton has found favour with the student. It is clearly written, without unnecessary elaboration, and that there was room for a book of this kind is evident, as a fifth edition has been called for. Accompanying the 263 pages of text and index there are 71 illustrations, and in the practical course a number of exercises are presented. It has not been deemed necessary to make any material alterations in this edition, and those who are about to commence a study of Metallurgy will find that it contains a great deal of helpful information. The various chapters deal with: (1) Properties of the Metals; (2) Combustion, &c.; (3) Fuels; (4) Refractory Materials; (5) Furnaces; (6) Occurrence of the Metals in Nature; (7) Preparation of the Ore for the Smelter; (8) Metallurgical Processes; (9) Iron-Preparation of Pig-Iron; (10) Malleable Iron; (11) Steel; (12) Mild Steel; (13) Copper; (14) Lead; (15) Zinc and Tin; (16) Silver; (17) Gold; (18) Mercury; (19) Alloys; (20) Applications of Electricity to Metallurgy.

Elementary Coal-Mining.—By Geo. L. Kerr. Price, 3s. 6d. 220 pp. 229 illustrations. London: Charles Griffin and Co., Ltd.

This elementary text-book, designed by the Author to meet the requirements of students attending classes on coal mining and of students and others engaged in practical work, is now in its third edition, and has been thoroughly revised, considerable alterations and additions being made. Good value is given for the 3s. 6d. expended in the purchase of the work, and a feature that we commend is the series of questions at the end of each chapter. By this means the diligent student is enabled to test his increasing knowledge if he is so disposed. The fourteen chapters treat on: (1) The Sources and Nature of Coal; (2) Exploration and Boring for Coal; (3) Breaking Ground; (4) Explosives, Blasting, &c.; (5) Sinking and Fitting of Shafts; (6) Modes of Working; (7) Timbering Roadways: Supporting Underground Workings; (8) Winding or Drawing Arrangements; (9) Haulage or Underground Conveyance of Coal; (10) Pumping and Drainage of Mines; (11) Ventilation of Mines, Gases, &c.; (12) Lighting of Mines; (13) Surface Arrangements, Cleaning and Sorting Coal; (14) Surveying, Levelling and Plans.

Sketches of Engine and Machine Details.—By Wallace Bentley, M.I.Mech.E. 5th Edition. 2s. 6d. net; abroad 3s. net. Halifax: The Bentley Publishing Co., Crossley Street.

This is a popular book among engineers, draughtsmen, and others, and should be serviceable as a text-book for machine construction and drawing classes. In the preparation of the edition before us the opportunity has been taken to revise the work, and some 30 pages of new drawings have been added. Altogether, the book now contains over 250 detail drawings fully dimensioned, taken from working drawings supplied by over 60 eminent engineers and engineering firms. Many of the drawings are accompanied by rules and formulæ, and the book may be accepted as representing modern practice in the shop. It should certainly be in the hands of the draughtsman.

Explosives and Shot-Firing in Coal Mining.—By Henry Davies. Price, 1s. 6d. Cardiff: Western Mail, Limited.

This is a new book by Henry Davies, who is the Director of Mining Instruction for the County of Glamorgan. It contains several features not commonly included in ordinary text-books, and shot-firers and others in the mine will find much material within its 94 pages that is well worthy of careful study. The desirability is recognised for an extension of a theoretical knowledge of explosives. In the issue of his simple treatise Mr. Davies is actuated by the desire to present instruction that may lead to a reduction of explosions and accidents arising from the misuse of explosives, and at the moderate price of eighteenpence there should be a wide demand for the manual. The instruction and information embodies: (*a*) Classification of explosives; (*b*) practical tests; (*c*) explosives suitable for coal mining; (*d*) manufacture and composition of explosives; (*e*) appliances used; (*f*) accidents in the use of explosives; (*g*) prevention of accidents; (*h*) precautions before firing; (*i*) leaves from a shot-fireman's diary; (*j*) leaves from an inspector's note-book; (*k*) dangerous practices; (*l*) precautions. This book on Explosives and Shot-Firing can certainly be recommended to workers in the coal mine. It is written in plain language that may be understood by the humblest worker. Copies of this book can be obtained direct from the Office of *The Science and Art of Mining*.

RESCUE STATION FOR THE RHONDDA.

Notwithstanding the industrial troubles in the coalfield, the South Wales and Monmouthshire Coalowners' Association have not relaxed their efforts to safeguard the lives of the men in their employ. In addition to the rescue stations already opened, another will shortly be available at Appletree, near Porth. In this rescue station, which will be the first to be established in the Rhondda, the oxygen will be generated and stored in cylinders, and electricity produced for the arc lamps to be used in case of disaster. Sulphur will be produced in a special apartment to fill two galleries, where the men will be trained for their rescue work. Ten men, the *Western Mail* says, can be instructed in each gallery, so that twenty men may be put through a course of instruction at one time. The galleries will represent a heading underground, rails being laid down for trams, and there will be representations of a fall of roof. A room will be provided where men can change their clothing and don the rescue apparatus. There will be telephonic communication with all the collieries in the Rhondda, and the instructor, Mr. J. H. Thorne, will have a motor car for use at a moment's notice to convey rescue parties to any particular place. Mr. J. H. Thorne was for eight years an official at the Wharncliffe Silkstone Colliery, near Barnsley, Yorkshire, and, after occupying responsible positions at other collieries, commenced training in rescue work about nine years ago at the Tankersley Pits. He was instrumental in saving life at the Hamstead Colliery disaster, near Birmingham, when for a time twenty-five men were entombed, and he was awarded the King Edward medal. On another occasion an electric haulage engine got on fire a mile in the workings at Wharncliffe, and the rescue apparatus was quickly on the spot under his supervision. At the Maypole Colliery, near Wigan, which took fire, the rescue appliances were unavailing, although ready for use, as the mine had to be flooded. An attempt was made to save some of the victims of the Whitehaven catastrophe, but the party could not get within 150 yards of the fire, owing to the intense heat, and had to abandon the effort. For this a bar was added to Mr. Thorne's King Edward medal, as he narrowly escaped death by his gallant endeavour to save life.

YORKSHIRE COLLIERY MANAGERS.

At a meeting of the Yorkshire Branch of the National Association of Colliery Managers, held at Wakefield on the 2nd inst., it was announced that the ballot for the election of officers for the ensuing year had resulted as follows:—President, Mr. James Elce; branch council, Messrs. J. J. Eley, S. Gill, P. Darlington, F. H. Waterhouse, T. Beach, G. H. Barraclough, S. R. Chadwick, and Jonathan Wroe; secretary and treasurer, Mr. J. R. Wilkinson; auditors, Messrs. E. Keightley and T. H. Brierley; representative to the Sheffield University Mining Committee, Mr. J. Elce; representative to the Leeds University Mining Committee, Mr. John Gill. The annual report showed that the membership of the branch had increased during the year from 184 to 207. It was now the second largest branch in the country. Its representation on the general council of the Association had been increased from two to three. The credit balance on members' account had risen from £32 15s. to £61 6s. 10d., and that on under-managers' account from £10 18s. 5d. to £13 10s. 4d. Discussion was resumed on the paper by Mr. F. K. Cartwright, of Crigglestone, on "Gas caps, and a simple way of estimating the percentage of fire-damp in mines." One of the principal contributors was Mr. W. Kyle, of Orgreave Collieries, who exhibited an aluminium plate which destroys the luminosity of a safety-lamp and renders it possible to detect quantities of fire-damp well under one per cent., which would not be detected by an ordinary lamp.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

No. 7.—After-Damp and Colliery Explosions.

After-damp is the name given to the mixture of the gaseous products of an underground explosion and the unconsumed portions of the contributing atmosphere. It is of uncertain composition, varying with the circumstances of the explosion, and, as a rule, is possessed of deadly properties.

After-damp has always been recognised as being dangerous. In the early days the manner of its action was not clearly understood, probably owing to a want of knowledge of its real composition. It was considered to consist of a mixture of nitrogen, carbon dioxide, and vapour. It is now known that considerable quantities of *carbon monoxide* may be present in an after-damp, and that it consists of a mixture of carbon dioxide, carbon monoxide, water vapour, with nitrogen and unconsumed oxygen (from the original air current); and, occasionally, unconsumed fire-damp and traces of gases distilled from coal and other material by the passage of the explosion flame.

The deleterious effects were attributed chiefly to the nitrogen. Nitrogen is not poisonous, however, and the effects described by early investigators are now recognised as those produced by carbon monoxide, probably assisted, in the path of the explosion, by the extreme deficiency of oxygen it produces.

Undiluted after-damp may contain from two to ten per cent. of carbon monoxide, and the oxygen percentage may be less than five. Each of these effects is in itself dangerous. The latter is sufficiently low to produce an immediate loss of consciousness in a person exposed to the undiluted products of explosion, and in a short space of time the poisoning effects of the former will produce paralysis and death.

The deadly nature of the undiluted after-damp left in the track of an explosion is now apparent, suggesting extreme care when entering an atmosphere likely to contain such; and, to a person in the mine not incapacitated by the direct violence of an explosion, the need *for urgent retreat from the main air-ways and all air-ways likely to be passing the after-damp.*

In many cases of explosion, it would be safer to retire to parts of the mine in which the air could be made *stationary*, or isolated from the main current, rather than attempt to pass through the main air-ways to the shafts.

By mixing with fresh air, the dangerous activity of the after-damp may be reduced. This has the effect of restoring the oxygen percentage to reasonable proportions, but it will seldom be found that the admission of fresh air will *immediately* reduce the carbon monoxide to a safe percentage. As carbon monoxide gives no evidence of its presence, apart from physiological symptoms, an air-way apparently clear to a visual inspection, must be looked upon with suspicion for a considerable period after an explosion, if it is part of an air-current affected by the explosion or its products.

The proportion of the various gases entering into the composition of an after-damp depends, to a large extent, on the type and intensity of the explosion. The chemical re-actions involved in its formation are not generally understood, and from the nature and extent of the action, it is obviously impossible, from a superficial examination of the conditions previous to explosion, to predict the probable composition of the after-damp.

While in all probability the after-damp from a pure gas explosion will contain less carbon monoxide than would be produced by a coal dust explosion, both types are dangerous; and, owing to the uncertainty of formation, should be considered, in practice, as being equally dangerous.

The deadly nature of the after-damp may be illustrated by stating that of all deaths due to colliery explosions, 80 to 90 per cent. are caused by carbon monoxide poisoning. The summary of causes of death given by the Medical Officer in charge of the rescue work at Hulton is instructive:—

Deaths due to	Carbon Monoxide	224
,,	Explosion and CO	63
,,	Explosion alone	53
,,	Asphyxia	2
,,	Unstated Causes	3
,,	Shock and Burns (in Infirmary)	1

In all 287 deaths, or 81 per cent. of the total, were due to carbon monoxide. This includes the 63 cases affected by the direct violence of the explosive force.

Colliery Explosions.—The explosive properties of fire-damp have already been discussed.

In the early days of mining, the explosibility of fire-damp was persistently forced upon the attention by the hard facts of experience. As early as the 17th century we have records of the loss of life due to fire-damp explosions, and, probably long before this, fire-damp had come to be looked upon by the miner as a deadly enemy.

As in many cases of explosion there was a history of the presence of fire-damp *previous* to the explosion, it was natural to assume, in the absence of further knowledge, that *all* explosions were evidence of the existence of fire-damp at the time of the ignition. In those cases having no previous history of fire-damp in dangerous quantities, the explosion was accounted for by the theory of an outburst of gas, from some uncertain place, in sufficient quantity to *suddenly* fill the affected mine with an explosive mixture.

It has been shown that before a pure fire-damp explosion can occur and extend throughout a mine, there must be at least six per cent. of gas present in the air throughout the whole region traversed by the flame.

As no definite evidence of the *sudden* appearance of the large quantities of gas required to produce such an atmosphere at the time of an explosion had been established, and the probabilities of obtaining such were recognised as remote, the alternative of the existence of other inflammable substances began to be questioned. That such inflammable matter does exist is now well established, and *coal dust* is recognised as a formidable agent in the production and extention of colliery explosions.

As early as 1803, the effect of coal dust was incidentally referred to in a report on the Wallsend explosion on September 3rd of that year, in which it is stated that "the workings were very dry and dusty, and the survivors, who were the most distant from the point of explosion, were burnt by the shower of red hot sparks of the ignited dust which were driven along by the force of the explosion."

In reporting on the explosion at the Haswell Collieries in September, 1844, the late Professor Faraday said:—

"In considering the extent of the fire from the moment of explosion it is not to be supposed that fire-damp was its only fuel; the coal dust swept by the rush of wind and flame from the floor, roof, and walls of the works, would instantly take fire and burn if there were oxygen enough present in the air to support its combustion. . . . There is every reason to believe that much coal gas was made from this dust in the very air itself of the mine, by the flame of the fire-damp which raised and swept it along, and much of the carbon of this dust remained unburnt only from want of air."

The practical significance of this report was not apprehended; and nothing was done until Mr. Galloway took up the matter in 1870. In 1875 Mr. Galloway demonstrated that "a mixture or air and fire-damp which would not be inflammable alone, would become inflammable when coal dust was added." In 1880 he became convinced "that fire-damp is altogether unnecessary for the propagation of flame with explosive effects by a mixture of dry coal dust and air."

The persistent work of Mr. Galloway and other pioneers, and the imperative tone of public opinion following several serious explosions, notably that of Seaham Harbour in 1880, forcibly directed attention to the coal dust question. In the following years a large amount of experimental work was done by British and Continental Commissions on behalf of the various Governments, which confirmed the earlier work referred to above.

In 1891 a Royal Commission on Explosions from Coal Dust in Mines was appointed. A valuable report was issued in 1894 containing the conclusions of this Commission—a report which should be carefully studied by all mine officials.

A summary of the conclusions as given by the Commissioners in their report is as follows:—

1.—The danger of explosion in a mine in which gas exists even in very small quantities, is greatly increased by the presence of coal dust.

2.—A gas explosion in a fiery mine may be intensified and carried on indefinitely by coal dust raised by the explosion itself.

3.—Coal dust alone, without the presence of any gas, may cause a dangerous explosion if ignited by a blown-out shot or other violent inflammation. To produce such a result, however, the conditions must be exceptional, and are only likely to be produced on rare occasions.

4.—Different dusts are inflammable, and consequently dangerous, in varying degrees; but it cannot be said with absolute certainty that any dust is free from risk.

5.—There appears to be no probability that a dangerous explosion alone could ever be produced in a mine by a naked light or ordinary flame.

These conclusions have been confirmed by more recent work, with the exception of those parts referring to the sources of ignition. Such require to be modified; the latter conclusion (5) being particularly open to criticism.

At this point a brief account of certain past explosions may help to illustrate the effects of coal dust in various circumstances.

Seaham, September, 1880.—The explosion originated at a point about 100 or 150 yards from the shaft *in the main intake*, and at a very dusty place. An ordinary shot was fired in the stone.

The quantity of air passing was about 60,000 cubic feet per minute, and it was almost impossible that gas could have been present. Naked lights were used at the point of origin.

The explosion was confined to the main haulage roads, and did not reach any parts of the mine in which there was gas.

Risca, January, 1882.—The explosion is said to have originated *in a main intake* swept by an air-current of 60,000 cubic feet per minute, and at a spot from 200 to 300 yards from the bottom of the downcast shaft.

It is contended that no gas could have been present in this intake on account of the perfect ventilation, and the fact that the intake was in a stone drift.

It appears that four shots were fired, and it is suggested that the last shot to fire ignited the dust raised by the concussion of the previous shots.

The explosion proceeded along the main intake to the foot of the shaft, and thence went to bank. There was no trace of explosion in thoroughly wet places.

Altofts, October, 1886.—Three shots were fired in a main haulage road. It was a very dusty road. It is supposed that the first two shots raised the dust, and the third shot—being probably overcharged—fired it. The volume of air passing the place was 40,000 to 50,000 cubic feet per minute.

The main returns were practically free from gas, and no damage was done in any of them. Those roads containing coal dust were affected. No damage was noticed on wet roads, and roads containing stone dust or only a slight sprinkling of coal dust were not affected.

Camerton, November, 1893.—Previous to the explosion this colliery had worked for nearly one hundred years. During this time fire-damp *had not been seen*, and no precautions of any kind were taken against gas. Not the slightest trace of fire-damp was found after the explosion.

On the night of the explosion two shots were fired on the main incline. The second of these was evidently badly placed and overcharged, and, it is considered, ignited dust raised by the first shot. The immediate neighbourhood of the shot was particularly dusty and there was more or less dust throughout the incline. Coked dust was found in the track of the explosion.

The explosion travelled in both directions from the shot, increasing in force with the distance, and was finally arrested by a wet piece of roadway.

Brancepeth, 1896.—Shot-firing was conducted on the main engine-way, using, without authority, compressed gunpowder. The improper position of the hole produced the effect of a blown-out shot. The shot ignited the dust, and caused the death of twenty persons. There was no evidence of fire-damp being present. The mine was not considered dry or dusty, but there was evidently sufficient dust to cause an extensive explosion. A certain amount of watering was carried out, but this was insufficient to stop the explosion.

Micklefield, 1896.—Naked lights were in use at the colliery, and the conclusion was that a small quantity of fire-damp ignited at a naked light set up an extensive dust explosion. Fire-damp had only been found at rare intervals during a period of twenty-three years. The amount of dust was considered to be inconsiderable. Dust from the floor had been removed at intervals, and the floor watered with water tubs at irregular periods. Open tubs were in use. After the explosion precautions were taken for the complete watering of the mine and safety-lamps were introduced.

Drumpeller, 1898.—An explosion of coal dust on a main haulage road, due to firing a charge of *gunpowder* contrary to the Explosives Order. There was no attempt to water the place of firing, and there was evidence of negligence to see that the necessary precautions were taken. The explosion was not a violent one, but extended throughout the haulage road, and resulted in four deaths.

Universal, 1901.—An extensive dust explosion by which all persons in the pit at the time, except one, lost their lives. The explosion travelled through all the main roads, with the exception of a few portions naturally damp, and penetrated into the stall roads and working faces in each district, but avoided the principal return air-ways. There was evidence of the mine being dry and dusty throughout, except in a few places where there was natural moisture. The cause of the explosion was obscure, but Professor Galloway came to the conclusion that it originated from the firing of a shot in a roadway close to the face without any attempt being made to water the locality.

Liverpool District, 1901.—A charge of Permitted Explosive was fired on a haulage wheel in order to break it up for purpose of removal in a level near the main haulage brow in a dusty part of the mine. The shot was not placed in a drilled hole, or stemmed in any way, as required by the Explosives Order, and it appears to have been fired without the knowledge or consent of the superior officials. An explosion of coal dust occurred which travelled through the main roads. No gas was found by the inspector, and everything pointed towards the conclusion that the shot had ignited the dust, and that dust alone was responsible for the whole damage.

Probably sufficient cases have been mentioned to confirm the statement that fire-damp is not the only inflammable element in mines, and to convince the most sceptical of the danger attached to the presence of coal dust. It is only when this danger is fully recognised that the extensive violence and widespread destruction exhibited in the West Stanley, the Maypole, the Hulton, and numerous other disasters becomes intelligible.

NOTE.—A new book by Dr. J. S. Haldane, on *the Methods of Air Analysis* has recently been published by Charles Griffin and Co., Ltd.

It contains a detailed description of rapid and accurate methods of obtaining an analysis of the comparatively simple gas mixtures usually met in mines, and may be considered to replace *The Investigation of Mine Air* now out of print.

The methods of collecting samples of air in the mine are discussed in detail, as are the methods of manipulating laboratory apparatus and the principles involved in the process. Portable apparatus for the determination of fire-damp and the oxides of carbon, based on chemical principles, are described. There is also a description of the "Tube and Taper" test for oxygen determination, and of the flame test for fire-damp.

On the physiological effects of carbon monoxide and the method of determining small percentages of this gas, the author has the last word that can be said.

The book as a whole is a model of conciseness and lucidity; and to those students who have some knowledge of elementary chemistry should prove invaluable.

To the underground official unacquainted with the exactitude of scientific methods, it may prove difficult in parts, though well worth its price (5s. net) for the general information contained.

This book, which is beautifully printed and well illustrated, will undoubtedly have a wide influence; and, it is hoped, will lead to the establishment of more scientific methods of controlling the ventilation of mines than has hitherto been the custom in this country.—M.E.]

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q.—37,500 cubic feet of air per minute are passing along an air-way 10 feet by 5 feet, and 2,000 yards in length. What is the water-gauge? K = ·01.

A.—The pressure producing ventilation in a mine varies directly, of course, as the "water-gauge" which measures it, and since the pressure (p) in lb. per square foot equals water-gauge (W.G.) in inches × 5·2lb., then W.G." $= \frac{p}{5{\cdot}2}$

Now, $p = \frac{ksv^2}{a}$.

Where p = pressure producing ventilation in lb. per square foot;
k = coefficient of friction = ·01;
s = rubbing surface in square feet;
v^2 = (velocity of air in thousands of feet per minute)^2;
a = cross-section area in square feet.

Then

$$\text{W.G. in inches} = \frac{p}{5{\cdot}2} = \frac{ksv^2}{a \times 5{\cdot}2}.$$

Substituting the values of the question,

$$\text{W.G. in inches} = \frac{{\cdot}01 \times 2000 \times 3 \times 30 \times {\cdot}75 \times {\cdot}75}{50 \times 5{\cdot}2}.$$

$$= \frac{20{\cdot}25}{5{\cdot}2} = \text{nearly 4 inches W.G.}$$

Note that $v = \frac{q}{a} =$, in terms of the question, $\frac{37{,}500}{50^2} =$ 750 feet per minute = ·75 in thousands of feet per minute.

Or, since $v = \frac{q}{a}$, then $v^2 = \frac{q^2}{a^2}$, hence there is no absolute need to obtain the velocity when the quantity is given; the quantity taken, however, must be in thousands of cubic feet per minute, as for example —

$$\text{W.G. in inches} = \frac{ksq^2}{a^3 \times 5{\cdot}2}.$$

And substituting the values submitted in the question, then

$$\text{W.G. in inches} = \frac{{\cdot}01 \times 6000 \times 30 \times 37{\cdot}5 \times 37{\cdot}5}{50 \times 50 \times 50 \times 5{\cdot}2}.$$

$$= \frac{20{\cdot}25}{5{\cdot}2} = \text{nearly 4 inches (as before).}$$

It often saves time to avoid calculating the velocity from quantity and sectional area.

Q.—Suppose there was a large fall of roof in the main return air-way; what effect would it have on the water-gauge?—(Submitted by J. W. T.)

A.—The "inches of water-gauge" is a measure of the resistance encountered by the air-current in its passage through the roadways of a mine. If a large fall of roof occurs in the main return air-way, will it increase or decrease the amount of resistance due to friction of the air in that air-way? Whilst a more or less direct answer may be given to the question, it is considered advisable to deal with all the phenomena that would be expected from the occurrence of a large fall. It is assumed that "a large fall of roof" means such a fall as would reduce, but not totally block, the cross-section area of the air-way. Now, what are the phenomena attending the occurrence?

In the preceding question and answer it has been shown that $p = \frac{ksv^2}{a}$, and p = W.G. in inches × 5·2. What does this equation imply?

The pressure producing ventilation (p) may be expressed in "lb. per square foot"; in "inches of water-gauge"; or in "feet of motive column," as may be considered most convenient. It must be understood, however, that the pressure producing ventilation, as calculated from the above formula, relates to the pressure required to overcome friction only. Then, the pressure due to friction of the air-current is $p = \frac{ksv^2}{a}$.

From examination of this formula *four laws of friction* are clear, and these may be stated:—

(1) *The pressure required to overcome the friction of the air varies directly as the area of rubbing surface, "s."* The extent of the rubbing surface is found by multiplying the perimeter of an air-way by its length; thus, an air-way 5 feet × 8 feet, and 1,000 feet long has a perimeter of (5 + 8 + 5 + 8) = 26 feet, and its area of rubbing surface equals 26 × 1,000 = 26,000 square feet.

(2) *The pressure required to overcome the friction of the air varies directly as the square of the velocity, "v."* The velocity of the air is ascertained, usually, by the anemometer, and is measured by the distance traversed per unit time. It is generally understood, taking the *Atkinsonian* equation ($pa = ksv^2$) as a standard, that a double velocity given to the air does not meet with a double resistance due to friction, but with a double double, or four-fold frictional resistance. For if we double the velocity of the air we double the quantity in a given time, and since every particle of this double quantity meets every resistance with a double velocity, it follows that the frictional resistance will be four-fold. On the same understanding, it is feasible to say that if the velocity is reduced to half, the quantity will be reduced to half, and half the original quantity meets every resistance with only half the original velocity, hence the frictional resistance is reduced to $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$. But Mr. R. A. S. Redmayne, H.M. Chief Inspector of Mines,* doubts the accuracy of this statement, and shows in a footnote, that M. Rateau, by experiments carried out at the Montrambert Collieries on the whole mine, found that the "ventilating pressure increases as the 1·75th power of the volume."

Whether the ventilating pressure varies as the square, or the 1·75th power, of the velocity is really a matter of conjecture; but so long as modern mining books retain the Atkinsonian equation, and assert that "pressure varies as the square of the velocity"; and so long as the Mining Examination Boards retain that assertion, it will be to the student's advantage to keep in touch with the "law," even though it is only an approximate one.

(3) *The pressure required to overcome the friction of the air varies inversely as the cross-sectional area.*—The area of cross-section of an air-way, "a," is found by multiplying the width of the air-way by its height; thus, an air-way 8 feet × 5 feet has a sectional area of 8 × 5 = 40 square feet. The cross-section area of a circular air-way, say a colliery shaft, is found by (diameter)^2 × ·7854, or (radius)^2 × 3·1416.

(4) *The pressure required to overcome the friction of the air varies directly as the coefficient of friction.* The coefficient of friction, "k," may be expressed (like the force of friction) in "lb. pressure per square foot"; in "inches of water-gauge"; or in "feet of motive column." The determination of the coefficient of friction is a matter of great importance, for it denotes the pressure required to overcome the resistance encountered by the air per square foot of rubbing surface, due to the nature of that surface, when moved at the rate of 1,000 feet per minute. Then it is clearly seen that the actual value of the coefficient of friction is conjectural, unless very carefully determined by experiment, and even experiments may show different values in different mines, or even in different parts of the same mine. It is generally instructive and interesting to note the comparison of different values obtained under different

* "Modern Practice in Mining" by R. A. S. Redmayne, Vol. IV., page 69.

conditions. The generally accepted value of "k," suggested by Mr. Atkinson, gives 0·0217lb. pressure per square foot. This is equivalent, with the weight of air at ·0807lb. per cubic foot, to $\frac{·0217}{·0807} = ·2688$ feet of motive column; and also to $\frac{·0217}{5·2} = ·00417$ inch of water-gauge. The figures here used are based on the assumption that a cubic foot of air weighs ·0807lb., which would be equivalent to $\frac{5·2}{·0807} = 64·4$ feet of motive column; but it is now generally assumed for purposes of comparison, that the average weight per cubic foot of air for mine shafts is ·076lb., and this is equivalent to about 68 feet of motive column per inch of water-gauge.

Since the above figures are only conjectural, it would be instructive for students to work out their own equivalents to the various values given by different authorities; but to remember that the figures here given, and those usually given, are for a velocity in the air of thousands of feet per minute, hence, in the formula, Atkinson's coefficient of friction, as ·0217lb. pressure per square foot, or ·2688 foot of motive column, or ·00417 inch of water-gauge, may be taken as the value of "k" only when "v" is taken as thousands of feet per minute.

No other values have been mentioned as coefficients to this point because Atkinson's value is usually adopted at many of the Mining Examinations as a standard; but the writer, personally, considers Atkinson's value as too high, and prefers the adoption of Fairley's or Murgue's, which values are probably fairly well known.

These notes containing the conditions by which the pressure required to overcome the friction of air-currents may be measured are given as essential, and should be known by any mining student before he can study what the phenomena are likely to be when a large fall occurs in the main return. To summarise these conditions, when the fall occurs there is likely to be—

(*a*) A decrease in the perimeter of the air-course, and since the friction varies directly as the rubbing surface, and, hence, directly as the perimeter, one might expect a decrease in the friction, and, hence, a decrease in the water-gauge. But such a condition is only true when other conditions remain constant, which they do not.

(*b*) A decrease in the cross-section area of the roadway at the point of the fall, and since the friction varies inversely as the sectional area, a decreased area means an increased friction, and consequently an increased water-gauge—again when other conditions are constant.

(*c*) An increased velocity of the air; and since the friction varies directly as the square of the velocity—other conditions being constant—an increased velocity means a much more increased friction, and consequently an increased water-gauge.

(*d*) It is also probable that a slightly increased coefficient of friction would be produced, for the coefficient is increased with the roughness and curvature of the roadway.

At the place of the fall the roadway would resemble, to a great extent, the opening at a regulator or "artificial resistance," and since all the above conditions would alter at the same time, the resulting effect would be a compound one, the combination of which would give an *increased water-gauge*. No actual figures are required to show this, it will easily be seen; and what is quite as important is to remember the converse of the above, that a suddenly increased water-gauge is an indication, in a direct manner, most probably, of a fall in the main return.

THE WATER AGE?

The United States is passing rapidly from an agricultural country to an industrial one, and this transition is accompanied by a large increase in power consumption and an enormous drain on the fuel resources of the country. In 1900 (says an article in *Scribner's Magazine*, entitled "Water Power in Industrial Life") the coal mined in the United States was approximately 270,000,000 tons. In 1910 it was over 500,000,000 tons, an increase of 85 per cent., being accompanied by an increase in population of approximately 20 per cent. This doubling in the output of coal over a decade has been the rate of growth for some time, and if continued the extinction of our known coal deposits will be a question of a comparatively few years. The cost of mining coal is increasing every year, and will probably continue to do so, even with the improvements in methods. Due to the improvements in generating machinery, the efficiency of utilising the coal for power purposes is constantly being increased, but a natural limit is being approached. It is evident, without further argument, that the interests of the people demand a rapid development of all the water powers which will in any way tend to decrease the coal consumption. It has been estimated by the Geological Survey that the available water-power of the United States at minimum flow is approximately 36,000,000 horse-power, and that this can be increased five or six times by suitable storage facilities. A recent report by Commissioner Herbert Knox Smith states that 6,000,000 horse-power has been developed in the United States for electrical and other industrial purposes. Before the perfection of electrical apparatus and the possibilities of power transmission, it was necessary to utilise the water power at the point of development, and this reached its greatest application in the mills of New England. The possibility of developing the water power at the point where it exists, but of utilising the power at the places of greatest convenience, has been brought about by the use of electricity, and this has been an important feature in modern industrial undertakings. Of all the great transmission systems in this or any other country, however, that centring around San Francisco stands pre-eminent in the number of stations feeding into the one system, and in the very large numbers of miles of the high tension transmission. The high cost of fuel in this part of the country brought about the very early development of some of the water powers, and for a long time the history of electric power transmission in the United States was largely made up of that of the companies centring around San Francisco. The developments which started with the Nevada County and the Yuba River plants changed later into the Bay Counties System; then into the California Gas and Electric Corporation, and now, with the absorption of the local lighting company in San Francisco, into the great corporation known as the Pacific Gas and Electric Company, which is the greatest hydro-electric transmission system in existence. On this system will be found the milestones which marked the progress of the development of the art, and it is interesting to note that in many of the stations the inductor alternator, now a practically obsolete type of machine in this country, is still to be found. In addition to the great system of the Pacific Gas and Electric Company, there are two powerful enterprises, the Great Western Power Company and the Sierra and San Francisco Power Company, which feed into the same power market, and which one might naturally expect would at some future time all be consolidated into one big system. The Pacific Gas and Electric Company, which is the best illustration of a large transmission system, has installed in water power plants a capacity of 93,000 horse-power, and in steam plants about 96,000 horse-power on the entire system. The water storage of these plants for both power and irrigation would be sufficient to supply the city of San Francisco with water for two years. There are over 550 miles of ditches and flumes, and nearly thirteen miles of pipe-line. Fifty-one electric generators supply the energy delivered to the overhead wires, being driven by water wheels, steam turbines, and engines.

THE MINIMUM WAGE BOARDS.

The following is a list of chairmen appointed under the Minimum Wage Act: *Northumberland*, Lord Mersey. *Durham*, Sir Robert Romer. *Cleveland*, Sir Robert Romer. *Cumberland*, Sir William J. Collins. *Lancashire and Cheshire*, His Honour Judge Bradbury. *West Yorkshire* (to be appointed). *South Yorkshire*, Sir Edward Clarke, K.C. *Nottinghamshire*, Mr. F. Y. Stanger, K.C. *Derbyshire* (except South Derbyshire), His Honour Judge the Hon. Walter Lindley. *South Derbyshire*, Mr. A. A. Hudson, K.C. *Leicestershire*, His Honour Judge O'Connor, K.C. *North Staffordshire*, His Honour Judge Bradbury. *South Staffordshire* (except Cannock Chase), and *East Worcestershire*, Sir Walter Lawrence, C.C.I.E. *Cannock Chase*, Sir Clarendon Hyde. *Warwickshire*, Sir Walter Lawrence, G.C.I.E. *Shropshire*, Mr. B. Francis-Williams, K.C. *North Wales*, Mr. B. Francis-Williams, K.C. *Bristol*, Alderman G. Pearson. *Forest of Dean*, Mr. Russell J. Kerr. *Somerset*, His Honour Judge Austin, the Hon. George Peel, Alderman T. Smith. *South Wales* (including Monmouth), Viscount St. Aldwyn. *Scotland*, Sheriff A. O. M. Mackenzie, K.C., Sir Thos. Mason, Mr. John Burnett.

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The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, MAY 11, 1912.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Will some kind reader please enlighten me on the following subject :—

A Tangye pump recently installed has been fitted with an air-vessel to the suction pipe. Please say what benefit (if any) this would be.

Yours, &c.,

"JAY BEE."

To the Editor of The Science and Art of Mining.

SIR,—Kindly publish the following :—

A 3-inch diameter pipe, 600 yards long, with a total rise of 75 feet :—

(1). How many gallons of water does the pipe contain ?

(2). What pressure per square inch is there at the pump when the pipe line is full of water ?

Suppose one pump is started, and pumps at the rate of 50 gallons per minute through the pipe—

(1). What pressure per square inch will there be at the pump ?

Suppose two pumps of 50 gallons capacity each are pumping through the same pipe—

(1). What pressure per square inch will there be at the pumps?

Yours, &c.,

MINING STUDENT.

To the Editor of The Science and Art of Mining.

SIR,—Will any of your readers kindly solve the following equation :—

Find the value of x when $x + \left\{\frac{x^2}{100}\right\} = 119$.

Yours, &c.,

LEARNER.

Geology.

To the Editor of The Science and Art of Mining.

SIR,—In further reference to the question of anthracite mined from the Silurian strata.

Mr. MORGAN in his first letter desired information from other authorities besides those stated in my answer in respect to the above question. Such information was duly given, and also a possible reason for the statement found in so many text-books, viz., anthracite mined from Silurian strata. As stated, I was not dealing with the case in an accurate sense. I certainly admit science should teach accuracy, especially when searching for coal. Yet geological strata during such process should not entirely be depended upon. Guided solely by the same it would be inadvisable boring any further than the Carboniferous strata. But graphite has been found in the oldest rocks, and has even been mined from the Silurian in Cumberland. Vegetable matter in the last stage of compression forms graphite. Taking such for the theory of its formation, I consider it possible for coal also to be found in the older rocks, as its origination is due to the same influences as the origination of graphite, although not in such a marked degree. Mr. MORGAN says that graphite may be formed from inorganic matter, yet it should not be taken for granted that the graphite found in the above-named strata has been so formed. That at one time graphite was vegetable matter, changing into its present condition through the influences of heat and compression, is the theory of formation that appears the more conceivable. The metamorphic rocks were once sedimentary matter, conversion into the present form being caused by compression and heat. Therefore, if the physical conditions (air, moisture, sunshine, &c.) of the universe at that period were such that waste of rocks was caused by their influences, it would also have been possible for vegetation to have grown as the conditions would certainly be favourable. Compression converts wood into coal, then through the various stages into graphite. The condition of the rocks constituting the earth's crust is also due to compression, therefore, the above theory relating to the formation of graphite is in accordance. Mr. MORGAN says I have not proved the actual mining of coal from Silurian strata. In answer I can only refer back to what I have already written. When help is needed to answer questions we can only refer to our text-books, believing the same to be at least accurate. Although nearly all my text-books stated that anthracite had been mined from Silurian strata, I doubted it ; that is, in an accurate sense, yet I set the same down, thinking that there must be some truth in the statements, otherwise they would never have been written.

In conclusion, it may be difficult to prove the existence of carbon formed from vegetable matter in rocks older than the Carboniferous, yet the non-existence of such has not been definitely proved. As with other strata of the earth's crust, we can only theorise.

Yours, &c.,

C. SIMPSON.

[This subject is now closed.—ED.]

The Electrical Special Rules, a New Departure in Official Procedure.

To the Editor of The Science and Art of Mining.

SIR,—The colliery manager who requires to make himself acquainted with the Electrical Special Rules can obtain a copy through any book-seller for the small sum of 3d. (which includes postage), but on going through them he finds himself confronted (in Rule 12 relating to Cables) with a reference to the "Report No. 7 of the Engineering Standards Committee, revised March, 1910." The Rule states that the lead sheath or iron or steel armouring of a cable shall be of not less thickness than is recommended by the Engineering Standards Committee, in the report above named.

The officials responsible for drafting these rules have not vouchsafed in their footnote the price of this report, or the names of the publishers (Crosby Lockwood and Sons), but have left each individual who will need to go through these rules—and every book-seller to whom an enquiry is sent—to ferret out this information for himself. And, having obtained

this report, he will find the information required is contained in a number of tables which occupy the latter half of a report of eighteen foolscap pages.

I do not think there has been any previous instance of the Home Office putting out mining rules which were *not complete in themselves*, and it is difficult to understand why the Home Office did not make arrangements to reprint these tables as an appendix to the rules. It would have added only one or two-pence to the price.

It may be that an explanation of this new departure will be found in the fact that the Engineering Standards Committee is described as being "Supported by the Institutions of Civil Engineers, Mechanical Engineers, Naval Architects, Electrical Engineers, and the Iron and Steel Institute"; the report being published for the Committee by Crosby Lockwood and Sons, at the price of 5s. net.

Is it that the Treasury have refused to pay the expenses of this Committee, or even to pay a share of their expenses, and that the Committee, being thus compelled to charge 5s. for a limited circulation of the Report, to cover their expenses, have refused permission to the Home Office to print these tables at the end of the Electrical Rules?

The report in question, which is one of a long list of various Reports on Engineering Standards, published by the same Committee, at prices ranging from 1s. to 21s., is marked—"*Copyright: all rights reserved*," and, therefore, the tables contained in it cannot be reprinted without the permission of the Committee.

These rules are practically an Act of Parliament, and the result is that every person who needs or desires to make himself fully acquainted with the provisions of these rules, is compelled by Act of Parliament to purchase this expensive report; it is the only way he can obtain the information.

We see, on the one hand, the neglect of an official to fully describe this report, causing needless trouble and waste of time to a very large number of individual users of the rules; on the other hand, if the above explanation is correct, we can see that the unbusinesslike method of the Government *may* result in the Engineering Standards Committee deriving, by Act of Parliament, a very large profit from the sale of this report, and each person who pays 5s. for it has to pay that sum for just one small item of information relating to one section of the rules.

If the public are satisfied with this sort of thing, it is conceivable that this new method of procedure might be extended indefinitely, and we may, some day, have a set of rules bristling with references to information which can only be obtained by purchasing publications whose copyright is private property and whose owners are at liberty to charge any price they like for information which the public would be compelled by law to purchase.

Yours, &c.,

T. A. SOUTHERN.

["TYKE" proposes to deal with the questions submitted by "Mining Student" and "Learner" as space and time permit.]

FUSE AND MINERS' SQUIBS.

By CLARENCE HALL and SPENCER B. HOWELL.

From Technical Paper 7 of the U.S. Bureau of Mines we make the following extracts:—

Charges of explosives are fired by means of various devices. The particular device to be employed depends upon the kind of explosive to be fired and the conditions under which it is used. Dynamites, permissible explosives, and other detonating explosives are usually fired by means of detonators, which are themselves ignited by means of a fuse or by an electric current. When a detonator is fitted with a means of firing it by an electric current it is called an electric detonator.

Black blasting powder is ignited by means of electric igniters, fuse or miners' squibs. An electric igniter consists of a short tube of spirally wrapped paper, into which is fitted a metallic bridge, a composition like that on a match, a sulphur plug, and a pair of insulated wires, the whole so arranged that the composition may be fired by means of an electric current.

As electric igniters and electric detonators are embedded in the explosive to be fired and are isolated by means of the stemming (the material tamped on the charge) they are the safest means of igniting charges of explosives in fiery mines.

Fuse.—Fuse was formerly called "safety fuse," and the practice still obtains, though the word safety has come to mean something far beyond what it was intended to mean when originally applied to fuse.

Fuse, as now known, was invented in 1831 by William Bickford, of Cornwall, England. Before its invention straws containing finely granulated gunpowder were used for igniting charges of blasting powder. Metallic needles, similar to those still employed in some of the coal mines, were used to make an opening through the stemming from the charge to the mouth of the drill hole. The straws containing the gunpowder were pushed into the opening and formed a powder train for igniting the charge. As the rate of burning in this train of powder was fast and irregular, sometimes approaching an explosion, the use of a slow-burning paper to communicate the flame to the powder train was found necessary. The interval that elapsed between the application of the flame to the paper and the ignition of the powder train gave the miner more time to retreat to a place of safety. Sometimes, however, he was not successful, and the irregular burning of the powder train and paper exposed the miner to considerable risk. So, when fuse was placed on the market and its comparative safety and efficiency for firing charges of blasting powder became known, it was favourably received. Since then the use of fuse has steadily increased, and now hundreds of thousands of feet of fuse are used daily for firing blasts of explosives.

"Safety" fuse is defined by the British Explosives Act of 1875 as follows: "The term 'safety fuse' means a fuse for blasting which burns and does not explode, which does not contain its own means of ignition, and which is of such strength and construction, and contains an explosive in such quantity that the burning of such fuse will not communicate laterally with other fuse." The name "safety" was applied to this kind of fuse because the fuse, when used under actual working conditions, burned at a uniform rate and did not explode. The inventor did not claim, nor has it been generally accepted, that ordinary fuse can be used with safety in gaseous coal mines.

Squibs.—It was long ago observed that straws containing fine grains of gunpowder would ignite charges of blasting powder, even though the straws and their core of powder were not continuous from the charge to the mouth of the drill hole, because of the propelling force of the burning powder. The first miners' squibs consisted of such relatively short lengths of powder-filled straws. One of these when ignited would dart from the mouth of a drill hole to the charge of explosive through the opening previously made with the needle, and would ignite the charge when the core of powder had burned through. With such squibs, as with the early forms of fuse, the time that elapsed between the lighting of the squib and the explosion of the charge of powder was very short, hence a slow-burning paper taper was added to the squib to increase the interval. Modern miners' squibs have been perfected after this fashion. Each squib consists of a small paper tube about 4 inches long filled with a powder core, and has at one end a slow-burning paper taper or match.

Fuse: Classes.—The moisture conditions under which blasting is done vary widely, ranging from the blasting of very dry material to submarine work. Hence it is advisable to manufacture fuse adapted to these various conditions, and in this country fuse is made in five classes, as follows:—

1.—Fuse for use in dry material.
2.—Fuse for use in damp material.
3.—Fuse for use in wet material.
4.—Fuse for use in very wet material.
5.—Fuse for use in submarine work.

Class 1 is cheaply constructed, has no waterproof qualities, and requires great care in manipulation. Its use is small, and it is not considered reliable.

Class 2 is better than Class 1, but has not all the requirements of a good fuse. It will stand immersion under a few inches of water for a few minutes, but it is not recommended for general

use. This Class, as well as Class 1, is invariably subject to lateral sparking when burning.

Classes 3, 4 and 5 are well made. They will stand immersion in shallow water 30 minutes, 24 hours, and 96 hours respectively. In burning they show little, if any, lateral sparking or glowing. They usually burn quietly and steadily, and will not burst nor explode. In metalliferous mines, where it is often necessary to use different lengths of fuse at the same time in order to fire dependent shots, the projecting ends of the different lengths, if the fuse is of these grades, can be coiled and placed in the mouth of a drill hole to keep them from being cut by flying fragments of rock. The lateral sparking is rarely sufficient to ignite adjacent fuse or cause short-circuiting, and accordingly the practice can be followed with comparative safety.

During the manufacture of fuse such defects as local irregularities in thickness, which indicate that the powder train is not uniform or not continuous, are detected by mechanical means. In recent years X-ray devices have been used to detect gaps and other irregularities in the powder train.

Practical Conclusions.—Tests of fuse in inflammable gas mixtures were made, and show that when the quantity of powder per foot in a fuse is reduced, other conditions being constant, or nearly so, the relative safety from ignition of gas by the fuse increases. However, other conditions than those indicated in these tests are requisite before a fuse can be considered permissible for use in a coal mine that generates inflammable gases. These conditions are :—

1.—Good mechanical construction with regard to safety.
2.—Safe and reliable methods of igniting the fuse.
3.—A reliable fuse.

Taking up in detail each of the above-mentioned conditions, the facts regarding each may be stated as follows :—

1.—A fuse of good mechanical construction must conform to the following conditions :—

(*a*) A continuous uniform powder core. Any enlargement of the powder core that might cause side splitting would not be good mechanical construction ; neither would a fuse having breaks in the powder core be considered of good mechanical construction.

(*b*) A proper and sufficient ratio between the pressure required to burst the envelope of the fuse and the pressure produced within it by the burning powder train. This ratio may be considered a factor of safety, and should be large enough to always prevent the side splitting so common in fuse of Classes 1 and 2.

(*c*) A pliable waterproof envelope. Pliability is essential in order that the conditions under (*b*) may always prevail. Freedom from moisture should exist in order that missfires may not occur.

2.—As fuse does not contain its own means of ignition, safety and reliability of fuse ignition involves a discussion of the fuse igniter. Clearly any fuse igniter that when properly attached to a fuse ignites gas should be condemned, as well as any fuse igniter that fails to ignite the fuse with certainty. No great difficulty should be encountered in perfecting a safe and reliable fuse igniter, judging from the results obtained from samples of fuse igniters submitted to the Bureau for tests.

One of these fuse igniters fits on a fuse in the same manner as a detonator. One end of the igniter is closed, and the composition within it is ignited when pinched by a special crimper. This crimper is so made that it surrounds the enclosed end of the fuse igniter. The tests of this fuse igniter were made in the same manner as tests with fuse. A part of the crimper and the fuse igniter were placed in the gas mixture. The sample of fuse used was of such a length that the time interval between the ignition of the fuse igniter and the splitting of the open end of the fuse was adequate for determining that the ignition was not caused by the spit of the free end of the fuse. Out of 17 trials one ignition occurred. This ignition took place on pinching the fuse igniter, and was due to the flame projected from the igniter. The fuse igniter was tested for reliability by crimping it on a piece of fuse and attempting to ignite the fuse by its use. In 46 trials the fuse igniter failed five times to ignite the fuse, and therefore this fuse igniter cannot be considered reliable.

Another fuse igniter, which operates on the principle of an enclosed friction "safety" match, was tested informally, and a small number of tests showed no unfavourable results as regards either safety or reliability.

3.—A reliable fuse should have a uniform rate of burning, and its spit should not fail to ignite the explosive or detonator with which the fuse is used.

It should not be concluded, however, that any fuse having the proper envelope and proper weight of powder per foot will necessarily pass the requirements, regardless of the composition of the powder or of its fineness ; nor should the use of any fuse, even when a safe and reliable method is provided for its ignition, be assumed to be safe in a body of inflammable gas.

Precautions to be Taken in Use.—Careful tests should be made of the rate of burning of fuse whenever there is any doubt as to its soundness. The manufacturers may produce a fuse with a regular rate of burning, but the rate may be changed by bad handling—for instance, by squeezing the fuse so as to disturb the powder train, or by suddenly and roughly opening the coil when it is stiff from cold so as to crack the fuse—or the fuse may be bruised by rubbing against the rough surfaces of rock.

Fuse should be carefully handled and never laid in a damp place before using. In cutting the fuse and in fitting it into place, care must be taken that the powder core does not run out of the fuse, for that might cause a missfire. The fuse should be cut straight across with a sharp knife just before placing the end in the detonator. In a humid atmosphere at least 1 inch should be cut off the fuse before insertion in the detonator. The fuse should be fitted gently into the detonator, and then the detonator should be crimped on the fuse by the proper crimper.

The best method of inserting the detonator and attached fuse into a stick of explosive or primer is to open the top of the cartridge by unfolding the paper at the end, and to make with a wooden skewer a hole in the top of the cartridge, deep enough to allow the detonator to be pushed into the cartridge up to the line of crimping. The end of the paper envelope should then be gathered about the fuse, and the whole bound with twine so as to fasten the detonator and fuse properly in place. Extreme care should be taken that the fuse and detonator do not come apart, because if there is any space between the detonator and the fuse the explosion may be prevented altogether, or may be a very poor one. In addition, care should be taken that the detonator is not completely buried in the explosive, for if lateral sparking from the fuse occurs it may set fire to the explosive before the detonator is set off. This lateral sparking has been the common cause of inferior and dangerous explosions.

With all the care exercised by the manufacturers of "safety fuse" to perfect the quality of fuse, human life depends in a great measure on the proper use of fuse by the miner himself. He should have a better understanding than he usually has of the action of fuse, because, under certain conditions, there is always an inherent risk in its use.

GERMAN COAL PRODUCTION.

The German coal production in metric tons during the years 1910 and 1911 was as follows :—

	1911.	1910.
Hard coal	160,742,272	152,881,509
Lignite	73,516,789	69,104,867
Coke	25,405,108	23,600,362
Coal briquetts	4,990,988	4,441,239
Lignite briquetts	16,836,679	15,125,777

The production of coal and lignite by districts was as follows :—

	Coal.	*Lignite.*
Prussia	151,496,548	60,594,195
Bavaria	762,270	1,5419983
Saxony	5,420,877	4,324,854
Hesse	—	498,871
Brunswick	—	1,566,589
Saxon-Meiningen	11,266	—
Saxon-Altenburg	—	3,659,204
Anhalt	—	1,321,334
Alsace-Lorraine	3,051,311	—
Reuss	9,759	—
	160,742,272	73,516,789

PRIZE COMPETITION.

"Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage: the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, May 21st, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[*In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 21, Vol. XXII., but in No. 22, Vol. XXII.*]

PREPARATORY.

Q. 1. COAL MINES ACT.—*In your own words what are the requirements relating to inspection of machinery?*

Q. 2. RESCUE WORK.—*What is your opinion as to the value of rescue apparatus underground?*

Q. 3. VENTILATION.—*Explain the action of the forcing fan and the exhausting fan in producing ventilation.*

Q. 4. ENGINEERING.—*What is meant by each of the following terms:* (a) *Indicated horse-power;* (b) *lap;* (c) *lead;* (d) *non-condensing engine;* (e) *compound condensing engine?*

SECOND CLASS.

Q. 5. GEOLOGY.—*Discuss the use of geology to the mining engineer.*

Q. 6. SLUDGER PUMP.—*Give a sketch of the sludger pump, and describe its use in boring.*

Q. 7. ELECTRICITY IN MINES.—*What are the advantages and disadvantages of earthing electrical machines and cables underground?*

Q. 8. VENTILATION.—*What gases would you expect to find on opening an area that had been sealed for some considerable time owing to the presence of a gob-fire? How would you search for them, and how would you recognise them? Explain fully.*

FIRST CLASS.

Q. 9. ELECTRICITY RULES.—*What precautions require to be taken when electric cables are put in a shaft?*

Q. 10. BORING.—*Describe the operation of boring for coal by a method giving solid cores of the strata passed through.*

Q. 11. METHODS OF WORKING.—*How would you work a seam which is subject to spontaneous combustion so as to secure the maximum safety?*

Q. 12. HAULAGE.—*Describe two arrangements of haulage, and say under what conditions they are suitable respectively.*

Best Answers Received to Questions in No. 18, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Shafts.

Q. 1.—*Why are single shafts or outlets forbidden? What are the provisions of the Act upon this point?*

A.—Before the year 1887 single shafts or outlets for the mining of coal were very common. The use of one shaft only for winding, pumping, &c., characterised the early history of coal mining. But as time went on accidents began to happen to the winding machinery and other appliances in the shaft, whereby the workmen were imprisoned in the mine for different periods of time.

We only need to refer to the Hartley Pit disaster, in which about 204 men and boys lost their lives.

This was a single shaft, in which pumping appliances of tremendous weight were suspended. The accident was caused by the unexpected breaking of some part of this pumping arrangement, which fell down the shaft, carrying everything before it, thus making it impossible to save the entombed men. It was this sad catastrophe, I believe, that led to the prohibition of single shafts as the only means of ingress and egress to a mine.

Single shafts are forbidden for the following reasons:—

(*a*) One shaft as the only means of communication to a mine will necessitate some means of partition in the shaft for ventilating purposes. This is liable to sudden derangement from various causes in the shaft, and may result in serious consequences.

(*b*) Should anything happen to the winding appliances, &c., there is the possibility of the men being imprisoned until such defects are made right.

(*c*) They are risky and unsafe. Should anything happen to the shaft itself, say a sudden giving way of the bricking, a collapse of the shaft sides, serious consequences would evidently follow. With regard to the Hartley Colliery disaster, as referred to, had there been some other means of communication, probably most of the men would have escaped.

(*d*) Should anything happen to the shaft, or anything connected therewith, either temporary or serious, it means imprisonment for the men in the mine, or otherwise serious disasters.

(*e*) Single shafts are risky and unsafe, being only allowed under special circumstances.

The provisions of the C.M.R.A. in regard to the prohibition of single shafts are as follows:—

Rule 37 (*a*), Section 16, states that every mine must have two shafts or outlets, so as to have a connection and means

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

of communication with every seam that is at work, and as a means of affording capable and separate means of ingress and egress to the workmen employed in every such seam as a means of safety.

(*b*), Section 18 states that two shafts must not be nearer to one another than 15 yards, and makes provision by having the means of communication between them of not less dimensions than 4 feet high and 4 feet wide.

(*c*), Section 16 makes provision for proper appliances being kept at every such shaft or outlet for raising and lowering persons, and such appliances to be kept in working order for emergencies.

Original, except reference to the C.M.R.A.

Thos. Gaskell, 138, Downall Green Road, Bryn.

[NOTE.—It is difficult to imagine that there could ever be a time when mines generally were permitted to be worked by a single shaft. Undoubtedly, the Hartley disaster was the direct cause of the Act being framed to compel the use of two shafts, except under certain circumstances. To think of intake and return air passing through the same shaft, and pump rods working there also, together with coal winding taking place in one shaft, and looked upon as quite the proper thing, and not as only a very temporary arrangement, as in a sinking pit, requires a very big stretch of the imagination. One has only to read the graphic account of the Hartley disaster written by one of the rescuers in *The Science and Art of Mining* a few weeks back, to understand why single shafts are forbidden. Of course, there are exceptions to the rule, and under certain conditions exemptions may be obtained from the Secretary of State.—C.C.M.]

J. C. Rodman, F. Mitchard, A. Davies, W. Williams, E. R. Hindle, J. Rainford, M. Greenall, W. Atherton, T. U. Parr, J. Taylor, F. Brooks, D. McBurnie, J. Brooks, C. Simpson, W. S. Hilton (*12 marks each*).

L. J. Thomas (*8 marks*).

Explosives.

Q. 2.—*Mention the precautions you would take before using explosives on the Permitted List in order to ensure safety.*

A.—In dry and dusty mines where fire-damp is occasionally given off only explosives on the Permitted List are allowed to be used. For shot-firing in underground roadways and working faces electricity produced from a small battery is the only power allowed for the firing means. All detonators necessary for the firing of shots vary in strength, according to the igniting properties of the explosive. Shot-firers are guided in their duties by legislation, therefore all should be thoroughly conversant with the rules relating to the firing of shots drawn up under the C.M.R.A. and also the Special Rules. Should these be followed out in their entirety then danger will be reduced to the minimum.

In respect to shot-firing under the above conditions, I would adopt the following precautions. Make a thorough examination for gas in the place where the shot is to be fired, in accordance with General Rule 12 (*f*). Should inflammable gas be present suspend firing operations until it was efficiently cleared away. Do not on any consideration fire a shot in any of the other places of the same ventilating district. In underground working faces (we will assume shots are being fired in the coal) shots are allowed to be fired only one at a time; when starting to fire start at the return end of the district, if possible. By so doing the powder fumes would always be behind, and not interfere with the work. Again, further safety would be ensured, because if any gas was liberated by the shots, it would be taken back by the return air-current clear of the remaining shots. Proceed to the first place, and should it be clear of gas carry out the firing operation as follows. First measure the shot-hole, that is, its depth, also the depth of the kirving. Such precaution is necessary because the shot-hole should not exceed the depth of the kirving. Should the shot-hole be greater in depth than the kirving, then more kirving would have to be taken out until their respective depths were the same as required by the rules of the colliery. Insert the cartridges of explosive in the usual way by pressing the first one gently yet firmly to the back of the hole; then the remaining cartridges necessary with the detonator inserted in the last one. Press them firmly one against the other, at the same time using care. Tamp in the usual way, of course, using material of a non-inflammable character, and tamp back to the mouth of the shot-hole. I would then make another inspection for a twenty yards' radius to convince myself that the place is still clear of gas. Should all be satisfactory, couple up the cable wires to those of the detonator, seeing that the connection was in proper order. After seeing everyone clear of the shot run out the cable to a place of safety, connect the same to the battery, give the usual firing signal, and operate in the usual way. After the exploding of the shot return to its vicinity, and make another examination in accordance with the rules. Should all be satisfactory, proceed to the next working place, and follow out the same operations, and so on until all shots are fired.

When firing shots in stone I would follow out the same procedure, as above described; that is, in respect to route, tamping, and charging of the hole, &c., but would see that the shot had not too much work to do or too little. In the first case a blown-out shot would be caused, whilst in the latter excessive flame, and such should always if possible be avoided, as the conditions would be rendered most dangerous. In respect to the use of explosives on main haulage roads and intakes, before firing all coal dust in the vicinity of the shot should be removed, and water applied for a twenty yards' radius. Under all shot-firing conditions in the mine adopt the following precautions:—

1.—When coal is being blasted have the kirving or undercutting greater in depth than the shot-hole.

2.—When stone is being blasted see that the explosive has not too much or too little work to do.

3.—The shot-holes are absolutely free from breaks, &c., as they have a tendency to cause blown-out shots.

4.—The vicinity of the shot for a twenty yards' radius is absolutely free from gas, and where coal dust is present thoroughly watered for such stated radius or distance.

5.—Have all shots necessary to be fired in main roads, &c., done at the week-end when all workmen, except those engaged in firing the shots, are out of the mine.

In conclusion, shot-firing in main haulage roads should be the last means thought of. I would carry all detonators in a box separate from the other explosives, and as a precaution against any being lost, count them before commencing my rounds and after. By adhering to the shot-firing rules, and adopting the foregoing precautions, danger in respect to the firing of shots even in gaseous and dusty mines will be greatly reduced.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

T. U. Parr, L. J. Thomas, W. Heaton, J. C. Rodman, T. Gaskell, F. Mitchard, W. Williams, E. R. Hindle, J. Rainford, A. Davies, M. Greenall, W. Atherton (*12 marks each*).

D. McBurnie, I. Taylor, J. Brooks, W. S. Hilton, W. May (*8 marks each*).

Machine v. Hand Work.

Q. 3.—*When would you substitute machine work for hand work, and what advantage would be gained in doing so?*

A.—The question of substituting coal-cutting machines for hand work should be very seriously considered before any definite step is taken, as it may be a great gain to the colliery company as regards reduced cost of getting and increased output, or it may be a dismal failure.

The success of machine work may depend upon many conditions and circumstances. If the getting price of the coal is low little advantage is to be gained by introducing machines. They have the greatest chance of success in thin, hard seams which are expensive to get by hand. There are, indeed, seams being worked by machines which could not be worked at a profit by hand. It should not be taken, however, that machines cannot be worked with success in thicker seams, for seams of varying thicknesses up to 6 feet are being successfully worked with coal-cutters. The roof should be fairly good where machines are introduced, or much trouble may be experienced with the timbering, especially as they require a considerable amount of room in which to work. It is not essential, however, that the roof should be good, although if it is tender and liable to slips a special method of timbering may be necessary. Machines

have the greatest chance of success where the long wall method of work is in vogue, as in this kind of work a long line of face can be obtained on which to work the machines. In any case, it is essential that there should be a straight line of face, free from steps, &c. It should not be supposed that machines are used only where the circumstances are most favourable, for the field for them is continually being extended, and they are now giving satisfactory results in seams of varying thicknesses, in seams which are steeply inclined, and under all kinds of roofs.

I would not discard hand work in favour of machine work in a seam where the getting price was low—where from my own experience and the experience of others I considered that no great saving could be made. This is the first and greatest consideration—economy in working.

If the holing or undercutting was hard, and, therefore, the advance slow and the output small, and an increased output was desired, then it would be to my advantage to employ machines. Also in a new pit or district where it was required to open out the face quickly machines could be introduced with advantage.

Then the method of work may not lend itself to the adoption of machines. If the face was stepped and uneven it would be necessary to work it into something like a straight line before machines could be used. Again, the hauling facilities may not be such as to cope successfully with the output.

Lastly, where the roof was very tender and subject to heavy and sudden weights, and where difficulty was experienced in keeping a road open along the face, I would not substitute machine work for hand work.

The advantages to be gained by the substitution of machines for hand work vary with the conditions obtaining, and are :—

The Reduced Cost of Getting.—This varies greatly under different conditions, there being in some cases a great saving, while in other cases no advantage is gained. Mr. H. W. Hughes, in his *Text Book of Coal Mining*, gives some instances of the reduced cost of getting through the introduction of machines. In a seam 4 feet thick the getting price has been reduced from 2s. 1½d. per ton by hand to 1s. 3½d., a difference of 10d. per ton, from which must be deducted the cost of working the machine, interest on capital, redemption, repairs, and renewals. At a Canadian colliery machine mining has reduced the getting cost by 6·62d. per ton, as compared with pick mining.

More Round Coal is Made.—It is estimated that under average conditions from 5 per cent. to 10 per cent. more round coal is made. This is due to the fact that machines only make a narrow cut, whereas, when the undercutting is done by hand, to hole a certain distance a man has to remove enough height of coal—about 1 foot or 18 inches—to enable him to get his arms in. In some cases the increase in the amount of round coal is much more than 10 per cent., as, for example, in a seam which is thin and hard, and holing has to be done in the coal by hand, whilst by machines it may be done in the underclay or in a dirt band.

The Output per Man is Increased.—The average output per man is increased by about one-third. In other words, the output from a given length of face is greatly increased for a smaller number of men employed, or the length of face required for a given output is lessened. Thus, a smaller length of roadways has to be constructed and kept in repair for any given output. The advantage of getting a greater output from a given length of face is very considerable in opening out new collieries, as they become remunerative long before they would do if developed by hand labour. There is the disadvantage, however, of additional capital being required when the mine is not paying.

Another great advantage as regards safety is that a regular system of timbering must be adopted and greater attention paid to the roof where machines are introduced. It has been found that the number of accidents in mines has been reduced by the use of coal-cutting machines and by regular timbering.

Besides the authority mentioned I have received assistance from Boulton's *Practical Coal Mining*, Vol. 2.

S. Beardsley, 8, Jackson Avenue, Ilkeston, Derby.

L. J. Thomas, J. C. Rodman, G. Winfield, T. Gaskell, F. Mitchard, W. Williams, J. Rainford, S. F. Middup, M. Greenall, T. U. Parr, J. Taylor, F. Brooks, J. Taylor, C. Simpson (*12 marks each*).

J. Brooks (*8 marks*).

Pumps and Pumping.

Q. 4.—*In driving to the dip, say, 1½ inches to 1 yard, and a mile from the shaft, how would you deal with a feeder of 25 gallons per minute?*

A.—To deal with this water I would have a small hand pump to pump it from the coal face to a lodge hole, where I would have an electrical pump fixed, which would be of the three-throw type, and capable of dealing with twenty-four hours' make of water in eight hours, so as not to have the pump continuously running, whilst it would also be capable of dealing with emergencies.

Then, gallons to be pumped per minute would be

$$\frac{25 \times 24}{8} + 10 \text{ per cent. for slip} = \text{say, } 83 \text{ per minute.}$$

Say the speed of pump equals 40 feet per minute. Then, size of rams can be found from the following :—

$$D = \sqrt{\frac{G}{\cdot 034 \times S \times N}}.$$

Let D = diameter of rams in inches ;
S = speed of rams in feet per minute ;
N = number of rams.

$$\therefore D = \sqrt{\frac{83}{\cdot 034 \times 40 \times 3}} = \sqrt{20 \cdot 34}.$$

Say, 4½-inch rams.

Assume a stroke of 1½ feet, then, number of revolutions

$$= \frac{40}{1\frac{1}{2} \times 2} = 13 \cdot 5 \text{ (approx.)}$$

The dip of the road is 1·5 inches to the yard.

$$\therefore \frac{36}{1 \cdot 5} = 1 \text{ in } 24.$$

Then, the vertical height the water would be lifted

$$= \frac{1 \times 1760 \times 3}{24} = 220 \text{ feet.}$$

Take efficiency of motor as 70 per cent., then horse-power would be as follows :—

$$\text{H.P.} = \frac{G \times 10 \times H}{33000}.$$

G = gallons per minute ;
10 = weight of a gallon of water in lb. ;
H = vertical lift of water.

$$\therefore \text{H.P.} = \frac{83 \times 10 \times 220 \times 100}{33000 \times 70} = 8.$$

Allow a voltage of 300 at motor, then number of amperes can be found from the following :—

$$\text{Volts} \times \text{amperes} = \text{watts, and } \frac{\text{Watts}}{\text{Volts}} = \text{amperes.}$$

$$\text{Then, } \frac{8 \times 746}{300} = \text{say, 20 amperes.}$$

The size of cables would be :—
Allow 1 square inch for 1,000 amperes.
Then, area of cables = $\frac{20}{1000}$ = ·02 square inch.

$$\text{Diameter} = \sqrt{\frac{\cdot 02}{\cdot 7854}} = \cdot 15 \text{ inch.}$$

Assisted by *G.E.S.*

John Cheetham, 11, Worsley Street, Lamberhead Green.

[Note.—We know many places where under circumstances similar to those mentioned in the question the water is being

filled into tanks and taken out to the pit, the quantity not being large. Of course, the objection to this lies in the fact that the water can only be taken out when the haulage is working, and assuming that the haulage only works eight hours out of the twenty-four it increases the actual quantity to be dealt with per minute to 75 gallons. Where we had endless rope haulage we should deal with the water by means of a set of three-throw pumps, say 4 or 5 inches in diameter, driven by the tightening wheel of the endless rope. If other than endless rope haulage were in use we could either drive our pumps by compressed air, if available, electricity, a combination of both, or a combination of electricity taken to a certain distance, and a rope for the remaining distance; but we should certainly drive by means of the endless rope if we had that class of haulage, and had power to spare.—C.C.M.]

J. C. Rodman, T. Gaskell, F. Mitchard, W. Williams, S. F. Middup, W. Atherton, A. Mills, C. Simpson, J. Bradshaw (*12 marks each*).

J. Brooks, L. J. Thomas (*8 marks each*).

SECOND CLASS.

Shot-Firing.

Q. 5.—*What precautions must be taken before and after firing a shot in a sinking pit?*

A.—*Precautions to be taken before Firing.*—(1) Providing that it is intended to fire the "sumping" shot first, and then the "caunch" holes, I would see that the latter were properly covered or protected by inserting wooden rods of the same length as the holes, but just a little less in diameter so as to enable them to fit snugly when inserted.

(2) The shaft sides should be carefully examined so as to locate any dangerous pieces, which are liable to fall when subjected to any disturbance, such as blasting. These, if any are discovered, should be properly spragged, or supported, in a temporary manner of course, but should be sufficiently durable to prevent them being detached when the firing takes place.

(3) Although, generally speaking, shot-firing is not attended in sinking operations with any serious degree of danger from dust and gas, as in a fiery mine, it is always advisable to examine for "blowers," especially if the sinking approaches a coal seam, or any carbonaceous strata likely to contain gas.

(4). All tools should be hoisted to bank before any connection is made between exploder and detonator wires. Also, when the sinking pit is ventilated by means of a fan at the surface with pipes carrying the air down to the bottom, it is often wise to disconnect the lowest section of the pipes and remove it higher up the shaft until the blasting operations are over; if this precaution is ignored the result is that a new pipe is necessary almost every week, which is a serious item economically considered.

(5). Before connections are made always make it a habit to systematically examine the "bowk"—its position in the shaft, and especially with regard to the attachment between "bowk" and the rope capping.

(6). If the shots are to be fired by fuses, it should be seen that the latter are of ample length, and with such a surplus as to make good any unexpected delay so common in such cases.

(7). To have all things in readiness for ascending once the fuses are ignited is an important precaution.

(8). The length of fuses employed varies according to the depth of the working; a deep shaft requires a longer fuse than a shallow one.

(9). To secure the detonators before firing the teeth should not be employed to execute the operation, neither should a knife composed of any metallic substance be employed, as fulminate of mercury, one of the prineipal constituents of detonators, is very sensitive, and a pin scratch is enough to fire it.

(10). The last man in the pit before firing should be the authorised person for such duties, and no sinker or any interested spectator should meddle with the battery box at bank while the shotman is connecting below.

(11). Everyone should be clear of the shaft eye when the firing is carried on; neglect of this simple precaution has resulted in many accidents.

Precautions after Firing.—(1). Immediately after blasting the shotman must disconnect the cable and battery. and place the latter safely out of reach. He should remove the plug or handle, and keep it in his possession.

(2). An open or naked light should never be allowed to be taken down a shaft after firing, until it has been properly examined by the master-sinker by means of a locked safety-lamp, with a view of detecting any gas having possibly been liberated by the blasting. This is most important, in fact essential, when the shaft approaches a coal seam.

(3). The sinkers should not be permitted to descend the shaft until the master-sinker and a companion have first descended, and have found the atmosphere normal, and the shaft sides safe.

(4). The curbs and girders should be well examined, and all loose stones resting upon them carefully removed, lest they should subsequently fall upon the sinkers whilst at work at the bottom of the shaft.

(5). The master-sinker should when making his inspection, preparatory to re-commencing work, re-connect the detached air pipe so as to remove the gases and fumes resulting from the explosion. Great discomfort may often be experienced through an omission of this simple precaution.

(6). All loose stones should be "plucked" down or otherwise supported before commencing the filling in of the blasted stones.

(7). In all cases of accidents coolness and presence of mind are most important, for in any emergency case a cool and collected person is capable of doing great service.

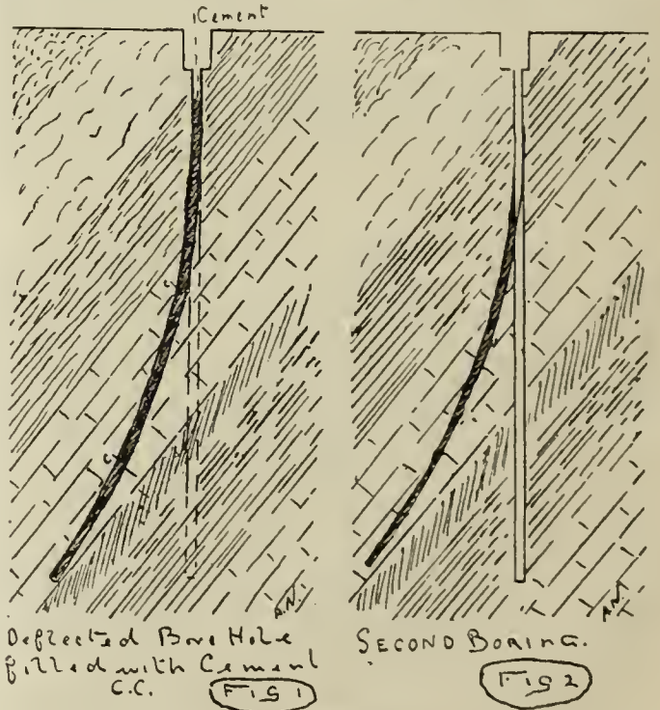
A. Nelson, Maes-y-Dyffryn, Glyn Neath, Glamorgan.

A. Stephens, W. A. Onley, J. Grundy, E. Ambrose (*12 marks each*).

Bore-Holes.

Q. 6.—*If a bore-hole was found to be off the vertical what means would you adopt to bring it back to its proper course?*

A.—By the use of bore-holes, preparatory to the sinking of the shafts, the nature and thickness of the strata to be penetrated are usually determined with a fair degree of accuracy. To provide strictly reliable and substantial data the bore-hole must be as near vertical as possible; otherwise it is more or less misleading. Formerly, it was thought that the diamond



Illustrating Question 6.

drill always bored a perfectly vertical hole, even when piercing strata of varying hardness and lying at steep inclinations; but of late practically all bore-holes of considerable depth

have been proved—by surveying and other methods—to have greatly deviated from the vertical plane. In certain cases the deviations have been so great as to reveal a state of things entirely out of order and misleading. These results prove that a bore-hole is of no practical use until it has been surveyed, and, therefore, no system is entirely reliable and trustworthy in giving a really vertical hole; further, a hole approximately plumb cannot be employed as a recommendation of the system, but rather of good luck in having favourable conditions of boring. The general rule is to consider the depth of the boring as being indicative of the vertical distance below the surface, but deflections from the vertical cause the termination of the hole to be shallower than it otherwise would be if it was maintained vertical.

The cause of these deflections varies. It may be attributed to loose or defectively screwed joints in the boring rods; in other cases by the strata being highly inclined and variable in hardness. Imagine, for instance, that the boring chisel, after penetrating the usual soft soils at the surface, came into immediate contact with a hard, flinty bed of rock lying at a high inclination; the chisel has a natural tendency to follow the soft ground, rather than face the new stratum. The result is a crooked hole. The same thing happens when boring is carried on in ground having hard massive rocks on one side, and soft shaly beds on the other; whilst it is easier to bore vertically in strata which are hard and compact right down from the surface, even though the same may be inclined. The rope systems of boring never give vertical holes, but are usually much out of it; in fact, some surveyed bore-holes prove that only a rope could reach their termination.

When the deviation of a bore-hole has developed to such a degree as to endanger the safety of the drill and rods, it is necessary and advisable to straighten it; for this purpose an apparatus termed the *clinograph* has been employed. First, the point where the bore-hole suddenly deflected is located, and then a washer consisting of good india-rubber is forced down to 20 or 25 feet below this point. Having done this, the liquid cement is prepared by mixing one part of cement with two parts of sand, and is then run in until it reaches a point some feet above the point of commencement of deviation. After allowing sufficient time to elapse to enable the cement to properly set and solidify, the boring tool is again lowered, and started gently, until it has secured a good start in its new and corrected path. Then the speed of cutting may be resumed as usual.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[NOTE.—At first thought it might be asked as to what was the reason why a bore-hole, on being found to be out of the perpendicular, should be brought back to its correct position, seeing that it is possible to survey such a bore-hole, and to find out how much it is out of the vertical. In such a case it would be possible to reduce the measurements of such inclined bore-holes to vertical measurements, in precisely the same manner as we reduce inclined measurements to horizontal ones. Further than this, a few feet of error in the depth of a bore-hole are not of supreme importance when prospecting with a view to sinking shafts. The chief reason, in our opinion, why it is necessary not to proceed with such a bore-hole after its deviation from the vertical has been discovered lies in the fact that there is an excessive amount of friction with the rods in such a bore-hole, which will eventually result in their breaking, and very possible total loss.

We should like to point out to several of our competitors that this question is not sufficiently answered when a description of how to find out whether a bore-hole is vertical or not has been given.—C.C.M.]

A. Stephens, R. Morgan (*12 marks each*).
E. Ambrose, J. Grundy (*8 marks each*).

Boilers.

Q. 7.—*If the water is found to be very low in a steam boiler (out of sight in the gauge glass) with the steam pressure up, and a brisk fire, state fully the steps that ought to be taken with the object of avoiding an explosion.*

A.—Decidedly, the conditions set in the above question are most likely to bring about a serious explosion, and immediate steps should be taken by the man in charge to alleviate the danger, otherwise the situation will develop to a very critical point. One of the most important points to be borne in mind by the attendant in charge of a boiler is the absolute necessity of maintaining an adequate supply of water in the boiler. Also when in charge he should frequently test the supply of water by means of the gauge-cocks, which are usually so situated or fixed on the boiler that by opening the upper gauge-cock the steam issues; when he opens the middle or intermediate cock water and steam escape; and when the lower gauge-cock is opened water only issues. By referring to the question we see that the water is dangerously low, even out of sight in the gauge glass, which possibly, when examined, shows steam, a sure indication that the water supply is far too low. Hence, the following briefly compiled "don'ts" are the precautions necessary to be taken in the order given, so as to avoid a disaster:

(1). Don't in any case pump into the boiler any water as the boiler plates are liable to crack, and thereby increase the danger of the situation.

(2). Don't rake the fire out, because the process involves an increase of heat, which is most undesirable.

(3). Don't lift the safety valve until the fires are withdrawn and the boiler allowed sufficient time to cool down.

(4). Don't change the state of the pump or engine which the boiler supplies with steam. If it is running let it continue so until the situation is less serious; if at rest do not start it.

(5). Don't do anything rashly, but maintain coolness, and carefully think over your plans before acting. Having determined the right and wise procedure, do not lose a second before putting it into operation.

The Reasons.—(1). It is dangerous to start the feed pump to inject more water. Seeing that the water is very low the boiler plates are excessively heated, and if allowed to come in contact with cold water are apt to become brittle and very liable to snap. One of the principal qualities of iron is that when heated it becomes quickly oxidised, and accordingly its cohesion and tenacity qualities are considerably lowered.

(2). The most natural and convenient thing to do is to start raking out the fire, but this operation creates an increase of heat by agitating the burning fuel, and exposing the hottest part of it, which is the interior to the boiler plates, thereby setting up increased evaporisation, which would lead to disastrous results in the boiler as in its present state.

(3). The safety valves should be left as they are found, for if any valve is opened, with the false idea of reducing the steam pressure by allowing some to escape, exactly the same amount as is liberated will again be generated, and thereby increase the danger by still reducing the water supply remaining in the boiler.

(4). It is also unwise to meddle with the engine for the same reason as lifting the safety valve, for if the engine is working when the seriousness of the situation is discovered a sudden stop would result in the recoil or flowing back of the steam, providing a serious danger. Therefore, it is advisable to allow it to run until the situation is less serious.

(5). It is absolutely necessary to keep good control over our actions, as in a case of this kind there are things that one would think most needed to be done, when on second thoughts they are seen to be the most dangerous and unwise proceeding possible.

Steps to be Taken.—The following are given in the order to be taken when acted:—

(1). The furnace doors should be opened as wide as possible, and smother the fire by means of damp sand or any loose soil that may be at hand. A few buckets of sand are most essential, and should be kept for emergency cases near the boiler. In my opinion, *moderately* damp sand is more effective than dry sand, but, on the other hand, if it is too wet it is liable to cause disturbance when thrown upon the fires, in which case a dry substance is to be preferred.

(2). Possibly by this time the fire is extinguished. In that case it may safely be raked out, but it should be left undisturbed if there exists any danger of increasing the heat.

(3). After these precautions are taken, the boiler should be left to cool down for about twenty or twenty-four hours before being supplied with water and the fires re-started.

A. Nelson, Maes-y-Dyffryn, Glyn Neath, Glamorgan.

[NOTE.—As we have mentioned before, the very steps which the ordinary man in the street would think proper to take under the circumstances mentioned in this question are the very ones which must on no account be resorted to. We must on no account open the safety-valve, and we must not attempt either to at once rake out the fires, or to extinguish them with water.—C.C.M.]

W. A. Onley, H. Jackson, A. Stephens, J. Grundy, P. Wilson (*12 marks each*).

J. H. Stephenson, E. Ambrose, J. Reid, R. Graham (*8 marks each*).

Air Compressors.

Q. 8.—*Describe an air compressor for use at mines.*

A.—With the advent of electricity in mines as a means of transmitting power, compressed air of late has found less favour, perhaps chiefly on account of its low efficiency as compared with electricity, but the latter must be, and is, considered a source of "potential" danger, especially at the faces and roadways a considerable distance from the shaft bottom. In these cases compressed air has an open field for rapid development, *i.e.*, unless electricity can be better controlled and rendered safer in the future than in the past.

The principle underlying the compression of air as a motive power is simply due to its elastic properties. Suppose, for instance, we have a cylinder full of air subjected to the normal pressure. Then introduce a piston and compress the confined air to half its volume; the force or power so exerted to compress the air is returned, immediately the power is exhausted, by means of the expansive properties of the air. Naturally, a certain amount of the pressure will have to be utilised to overcome the friction, which is present in a more or less degree in all power transmissions.

One of the most important points in the construction of air compressors is the absolute necessity of an efficient system of cooling. The Ingersoll-Sergeant Company realise this fact, and have constructed their compressor (see illustrations) accordingly. The essentials of high efficiency in compressors may be stated as follows:—

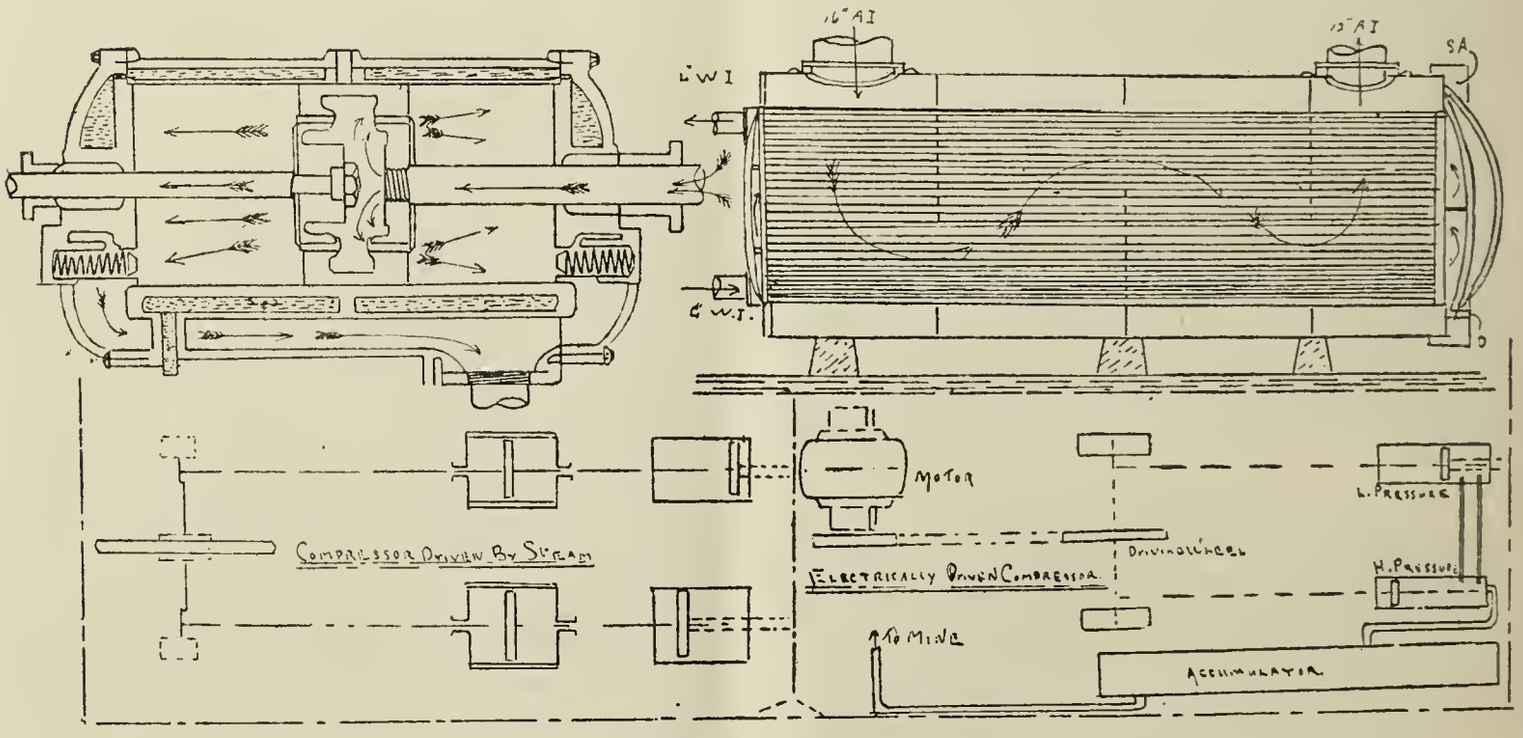
(1). The cooling surface offered to the air should be as high as possible.

(2). Whenever possible, the cooling agency, which is usually water, should have greater utility at the ends of the cylinder than at any other part. This is apparent, because it is at the ends of the cylinder that the heat due to compression is greatest, and, therefore, it is advantageous to have an extensive cooling surface offered to the air at those points.

(3). All air pockets and clearance spaces should be avoided, as any air remaining in the cylinder at the termination of the stroke—for example, in the recesses behind the exit valve—is wasted. Seeing that the inlet valve opens immediately the return stroke is commenced, the remnant of compressed air left at once falls to atmospheric pressure, to be again compressed.

(4). Valves should be of ample size, and quick in action; sluggish valves are utterly useless, because the incoming air and delivery flow are not controlled and actuated at the right instant. The result is a loss of efficiency. If the inlet or suction valves fail to open at the commencement of the stroke the air in the cylinder becomes attenuated, and creates a region of comparatively low pressure, with a consequent drag upon the piston. On the other hand, if they fail to close instantaneously with the return stroke, a portion of the air already compressed would be discharged into the atmosphere. Similar results ensue if the discharge valves are defective.

Construction of Ingersoll-Sergeant Compressor.—It consists of two cylinders driven by either an electric motor or by steam (see sketches), one a high pressure and the other a low pressure cylinder. Their approximate dimensions are: Low pressure cylinder, diameter from 16 to 17 inches, with a 10-inch stroke,



Illustrating Question 8.

the diameter of piston inlet is from 3 to 3½ inches. The high pressure cylinder is from 10 to 10½ inches diameter, with a 10-inch stroke. The diameter of the driving wheel is variable; 6 feet is a common size. The various points of the compressor are such as to conform as far as possible to the previously mentioned "essentials"; the valves are free to act at the right period of the stroke. Their movements are effected by air pressure and momentum, and each set of valves, *i.e.*, inlet and discharge, is well balanced, and admits of easy and accurate action. To enable the ends of the cylinder to be water-jacketed and employed as cooling surfaces, the inlet valves are fixed in the piston, consequently, the system of jacketing is a very practical and thorough process. In these spaces so provided, cold water is kept circulating, and its cooling influence is imparted to the valves, cylinder casing, and ends, and to the stuffing boxes. The air entering the cylinder is kept cool due to the fact that it passes through a stuffing box which is well jacketed. The jacketing may be thoroughly and cheaply carried in cases where a pump works, just by connecting its delivery pipe to the water inlet of the compressor.

Arrangement of Compressor and Driving Plant.—Accompanying this answer are two diagrammatic sketches of the methods of arranging the compressor, and (*a*) the steam plant (*b*) the electric motor. For the general idea of these sketches my thanks are due to my class teacher, Mr. B. RICHARDS, County Lecturer, from notes taken at class. As is seen, the compressor consists of a second cylinder placed in line, and directly behind the steam cylinder, the only difference being that it is slightly larger in diameter than the latter. The back piston rod of the engine is connected directly to the piston rod of the compressor. As the piston of the engine is on its forward stroke it carries with it the compressor rod, which compresses the air in its path, simultaneously opening the inlet valves and drawing in (by the suction principle) air from behind, thus providing a cylinder full of air in readiness for the back stroke. Towards the end of the forward stroke, as soon as the pressure of the air in the cylinder exceeds that of the air in the receiver, the delivery valve opens, and the air is forced into the receiver. During the momentary pause preparatory to the back stroke all the air having been forced out of the cylinder, the delivery or outlet valve closes, the inlet valves on this side of the piston open, while those on the other side close. The air in the other side is then compressed in exactly the same manner as described in the first case. Evidently, it is seen that at the commencement of the stroke the steam pressure is at its maximum, while the air resistance in the compressor is at its minimum. The result is, as the piston proceeds the force of the steam driving it forward gradually diminishes, while the air in front of the compressing piston tends to offer an increasing resistance, until at the end of the stroke the air resistance is at its maximum, while the steam pressure available is at its minimum. Consequently, the importance of a flywheel, or of arranging the compressors in pairs, with their cranks coupled at right angles, with the flywheel between.

Assisted by BOULTON'S *Practical Coal Mining.*

A. NELSON, Maes-y-Dyffryn, Glyn Neath, Glamorgan.

[NOTE.—This question met with a very small number of answers. Rather more was required than a simple description of the principle of an air compressor, such as one or two students sent in.—C.C.M.]

A. Stephens, E. Ambrose, J. Grundy, R. Graham (*12 marks each*).

FIRST CLASS.

Approaching Old Workings.

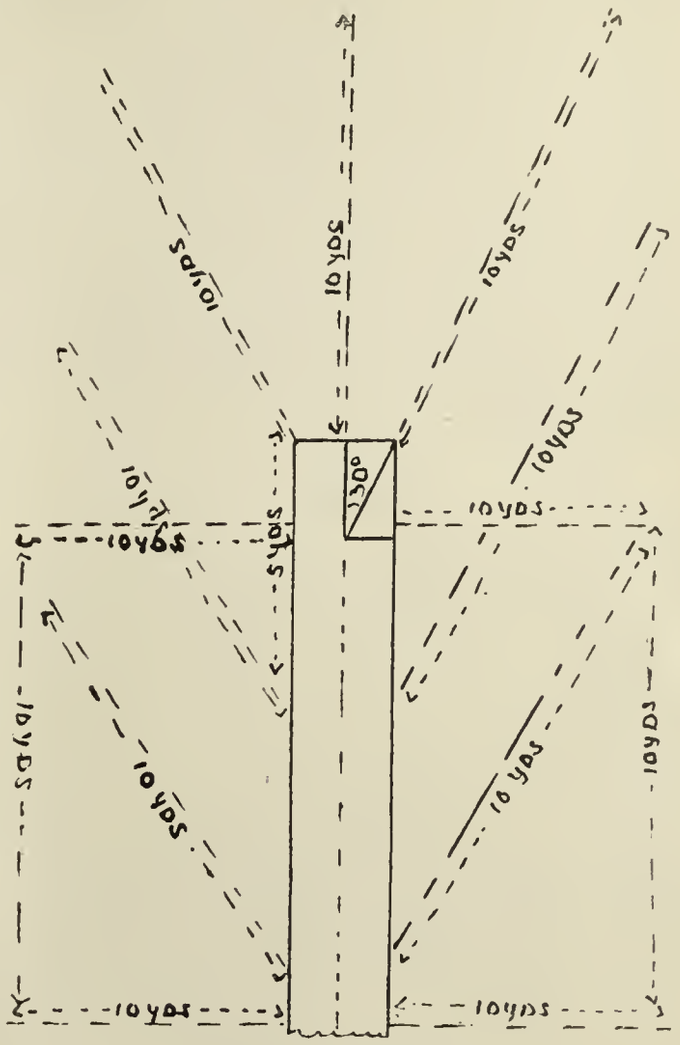
Q. 9.—*Give your reasons for having only one heading and 15 feet bore-holes in front and flank when approaching old workings of which no reliable plans can be found. Mention any other precautions you would use in such work.*

A.—Many serious accidents have occurred in coal mines on account of holing into old workings containing water. In some instances the old workings have not been actually holed into, but the barrier of coal dividing the old workings has been worked so thin that the pressure caused by the water in the old workings has burst the barrier, and thus flooded the workings of the mine, causing in some instances heavy loss of life.

It is advisable, therefore, when approaching old workings, especially as in this case when no reliable plans can be found, to just drive one heading in the direction of the supposed old workings so as to weaken as little as possible the barrier of coal intervening between the two workings.

The C.M.R.A., 1887, General Rule 13, states that where a place is likely to contain a dangerous accumulation of water the working approaching that place shall not exceed at any point within 40 yards of that place 8 feet in width, and there shall be constantly kept at a sufficient distance not being less than 5 yards in advance, at least one bore-hole near the centre of the working, and sufficient flank holes on each side. Now, as reliable plans of the old workings cannot be found, I should substitute instead of "not being less than 5 yards in advance," not being less than 10 yards in advance, also the same as regards the flank holes, as an extra precaution. I would also, say every 10 yards, have a hole bored in on either side, not at angles of 30° as would be the other flank holes, but at right angles to the heading; these holes would be the same depth as the others. We should then be able to ascertain whether the old workings extended further in one direction than another, and thus safeguard against working the coal too thin between the heading and the old workings.

If water was suspected at a high pressure it would be advisable to employ a boring machine, such as the Burnside machine. The special object of this machine is to control the sudden


10 yds
10 yds
10 yds

Anthracite.

Q. 10.—*Give an account of anthracite, and give some of the explanations of its mode of origin.*

A.—Coal may be defined as a mineralised vegetable matter which occurs in the crust of the earth in the form of regular stratified beds or seams, interstratified with beds of sandstone, shale, &c. It has been proved that, of all the various kinds of coal, anthracite is the furthest removed from the vegetable origin, consequently, anthracite is supposed to be the last stage in the conversion of vegetable matter into coal.

Anthracite, also known as stone coal or culm, is mined chiefly in South Wales, although it is mined in America, France, and Ireland. Its chemical composition differs to a marked extent from the other varieties of coal, being specially characterised by a very high percentage of carbon, and relatively small quantities of hydrogen, oxygen, and nitrogen. The quantity of ash is usually very low, although, as will be seen, the foreign anthracite coals contain a much larger percentage of ash. Many analyses have been made of anthracite, but each differs to a certain extent, this no doubt being due to the different samples analysed, and to the different authorities responsible for the analyses. The following is a table giving the chemical composition of various samples of anthracite, published in L. T. O'Shea's *Chemistry* :—

Locality and Seam.	*Carbon.*	*Hydrogen.*	*Nitrogen.*	*Oxygen.*	*Sulphur.*	*Ash.*
Welsh :—						
Timber Vein ..	93·00	3·08	0·54	1·67	0·68	1·03
Low Level ..	94·18	2·99	0·50	0·76	0·59	0·93
Kilgetty ..	93·27	2·72	0·18	2·47	0·15	1·21
Big Vein ..	92·56	2·11	4·68		0·12	0·43
Brass Vein ..	91·11	3·58	3·42		0·59	1·51
American :—						
Pennsylvania ..	86·91	2·80	3·89		0·43	5·97
French :—						
Sable	87·22	2·49	3·39		..	6·90
Isire ..	91·00	1·49	0·85		..	4·00

Anthracite, as its name of stone coal implies, is of a very hard nature, and, indeed, it may be correctly said that it is the densest, hardest, and most lustrous of all the varieties of coal. It is jet black, possesses a most brilliant lustre, and does not soil the fingers when handled, like other coals. When it is being heated it splinters, ignites only with difficulty, is slowly consumed, and burns without smoke or flame, giving off intense heat. It requires a strong blast for combustion, and when in a state of perfect combustion a powerful display of brilliant colours is seen. Before being used it is broken up into comparatively small cubes. Anthracite is more brittle than the bituminous varieties of coal, and breaks with a conchoidal fracture. It is, of course, not a coking coal. Its specific gravity varies with different samples. On the average it may be said to vary from 1·4 to 1·5, but has been known to reach as much as 1·75.

Owing to the difficulty of igniting anthracite, and the difficulty of producing the necessary draught required for perfect combustion, it is not much used as a domestic coal, a further domestic objection being the absence of the "homely" blaze. Its smokeless character during combustion makes it exceedingly valuable for naval use, and it is also largely used for malting, hop-drying, smelting, lime-burning, glass making, &c. Owing to its hard nature it may be transported over large distances with a minimum of breakage. The ash from anthracite consists chiefly of silica, oxide of iron, and alumina.

Mode of Origin.—There are principally two theories as to the mode of origin of anthracite, but before considering these it would be perhaps as well to state that graphite or plumbago is an extreme kind of anthracite, and, therefore, supposed to be a further step removed from the vegetable origin. They consist of almost pure carbon, the volatile elements having been almost completely eliminated.

Age of Coal.—Carboniferous matter is found in rocks of all ages, and in nearly all kinds of sedimentary rocks. The graphite beds of Canada occur in rocks of Laurentian age. The anthracite of County Craven, Ireland, is of Silurian age. The great coalfields of Great Britain, Continental Europe, and United States are Carboniferous. The coalfields of New South Wales, Virginia, India, and China, Carboniferous and Permo-Carboniferous, the bituminous coals of New Zealand, Upper Cretaceous; the brown coals of South Hungary, Pennsylvania, and North Germany, Oolitic and Liassic; of New Zealand and Vienna basin, Miocene; and the lignite beds of Ireland, Pliocene; whilst extensive supplies of graphite are found in rocks of Laurentian age in Canada, quoting from Park's *Geology*. A study of these coalfields would reveal the fact that the variety of coal owes its distinctive character to its position, and that seams lowest in the geological order are anthracite and graphite.

Effects of Intrusive Dykes.—Where coal has assumed the character of anthracite it is supposed that the original coal has undergone some great change. This change is supposed to have been brought about by intense heat, the heat expelling the greater part of the volatile constituents which originally entered into the composition of the coal.

Intrusive dykes, or, in other words, intrusive volcanic rocks, in the form of igneous rocks and basalt, have a marked effect upon any seam of coal with which they come in contact. When these intrusive rocks have come in contact with seams of coal, in some cases the seam of coal has been charred or coked for a certain distance, or even been totally destroyed. However, the effects are not always destructive. According to Park's *Mining Geology*, various bituminous seams of coal have assumed the character of anthracite and graphite. Notably at Malvern Hills, in New Zealand, a seam of brown coal (lignite) was dehydrated and converted into anthracite of excellent quality by a sheet of basalt. Whilst, again, masses of sandstone with adhering layers of graphite are not of uncommon occurrence on the slopes of Mount Egmont, a volcano. Many other instances may be quoted, but these will suffice. The basalt has undoubtedly been erupted into the seam in a state of fusion, and the heat has been sufficient to expel the volatile constituents, and bring the condition of the coal to that of anthracite or graphite.

A rather different theory has to be considered in the case of the South Wales Coalfield. It is a well-known fact that the quality of coal is not uniform. It varies from highly bituminous on the east to the typical steam coals of the Rhondda Valley, to the almost pure anthracites of the Carmarthenshire and Pembrokeshire districts. While this change from bituminous to anthracite coals can be followed from east to west, the same change (but in a less degree) can be traced in any one district of the coal basin. The change in the quality of the coal is very difficult of explanation, as there are no intrusive volcanic rocks present in the coalfield to affect it, consequently high internal temperature must be the cause. The fact that the coals are more anthracite in one part of the coal seam than the other is explained by Sir A. Ramsay, according to whom by the greater disturbances the rocks have undergone in the western part of the coalfield, these disturbances have had the effect of distilling the coal.

All things considered, we must refer this change in the quality of the coal seams to the agency of high internal temperature. In fact, it has been established beyond doubt wherever observations have been made that the temperature increases with the depth. The seams of coal in some parts of the South Wales Coalfield are covered with a vertical thickness of strata amounting to from 10,000 to 12,000 feet, and as a natural consequence the temperature has been raised exceedingly high. With this temperature, and the gradual escape of the gases along faults, &c., there would be finally left as a residue a quality of coal resembling anthracite.

Walter Heys, 1, Walter Street, Huncoat, Accrington.
F. Hutchinson (*12 marks*).

Shot-Firing.

Q. 11.—*What is meant by simultaneous shot-firing? Do you favour the simultaneous firing of shots?*

A.—Under modern mining conditions shot-firing is a practically necessary operation, and one which must perforce be employed if the mine has to be successfully and economically worked, but, unfortunately, it is a most dangerous operation, and one that has undoubtedly been responsible for many mining

disasters. Shots may be either fired singly or simultaneously as preferred. Of course, by the term simultaneous shot-firing is meant the simultaneous firing of a number of shots. There are advantages and disadvantages for and against the single or simultaneous firing of shots. No hard and fast rule can be laid down as to which is the better method, this depending upon the existing conditions.

Sinking Pits.—It need hardly be said that the electric system is the rational method of blasting in sinking pits. By the simultaneous firing of shots much time and labour are saved, and after the charging of the shots they are more quickly fired and the men got back to their work in a shorter space of time. This is an important item in a sinking pit, to say nothing of the safety of conducting the shot-firing from a convenient and safe distance, the shot-firer being assured of his safety. Again, by the adoption of simultaneous shot-firing a greater total amount of work may be done, as each shot helps the other. There is, however, an element of danger in the event of miss-fires. Every shot-firer knows that it is quite possible during simultaneous blasting, say when firing four shots simultaneously, for three of the shots to explode and the fourth to miss-fire, even when the detonator and charge of the miss-fire are in good condition. This is due no doubt to using a *weak* battery. When this occurs the shot-firer may conclude that they have all exploded, and the men being allowed to continue working there may be an accident due to the unexploded charge being struck by a workman's tool. Or if the miss-fire is detected, the *debris* of the relieving hole may bury the detonator, causing loss of time and labour, and also causing a certain amount of danger. Notwithstanding these disadvantages, there is practically no other course to adopt in sinking pits than simultaneous shot-firing, the number of shots to be fired at one time depending upon the size of shaft, &c.

Shot-Firing in Mines.—The conditions under which shot-firing is performed in mines are so different from those in a sinking pit that no true comparison can be made between them. Taking all things into consideration, I must say that I do not favour simultaneous shot-firing in mines, but speaking from practical experience I must confess that simultaneous shot-firing does possess advantages over and above the operation of firing all shots singly.

When firing say two shots simultaneously in a ripping caunch, each charge may be equally powdered, or at least the amount of explosive in each shot-hole may be left to the shot-firer's discretion. In this way each shot may be expected to help the other. Personally I have seen thousands of shots fired, and I may say that by firing two such ripping shots simultaneously instead of singly, the same amount of material may be brought down with a smaller charge of explosive. Again, by firing these shots simultaneously time and labour may be saved. When firing the shots singly three examinations must be made, once before the firing of the shots, after the firing of the first shot and before the fising of the second, and also after the firing of the last shot. In the case of simultaneous shot-firing two examinations for gas, coal dust, &c., must be made only, once before the firing of the shots and once after. This allows more time to be spent in the preparation of the shot.

A great disadvantage is the uncertainty of both shots being fired. As I have instanced in the case of sinking pits, one of the shots may explode and the other miss-fire, even though the charge of the latter be in correct order. I have seen such instances occur, and also it must be remembered that, where the charges have been proportioned so as to help each other, the single shot may fail to bring down its proportion of work and so cause a blown-out shot. When shots are fired simultaneously there is a greater "detonating" effect due to the exploding of a larger amount of explosive, and also there will be a greater amount of flame produced at the moment of firing.

I may also mention that, when firing two ripping shots simultaneously, one may fail to explode although in good order, and the other, as I have seen occur, will bring down the whole of the rock, or at least enough to lead the shot-firer to the belief that both charges have exploded. One can easily imagine the danger of removing the *debris* with the ordinary tools instead of adopting the precautionary measure of removing the *debris* by hand. When firing shots singly, the shots must necessarily be proportioned according to the work to be done. As an instance I will suppose that two shots in a ripping caunch have to be fired. Both holes must in most cases be charged at the same time, because if this were not so the firing of the first hole may damage the remaining hole and render it unfit to fire.

The first hole to be fired, *i.e.*, the leading hole, should be more strongly powdered than the remaining hole, because this hole has more work to perform. Now if the charge has been badly proportioned this shot may perform the greater part of the work, even in some cases doing as much as almost exposing the charge of the other shot. Every shot-firer knows or should know that the C.M.R.A. and Special Rules do not allow a shot to be unrammed, so that when the remaining hole is fired, it is practically what is called an overcharged shot.

Again, the firing of the first shot may have stirred up a quantity of coal dust, or more probably liberated a quantity of inflammable gas, and if this is overlooked by the shot-firer when making his examination previous to the firing of the other hole, the danger of firing the second hole may be foreseen. More time and labour are taken up when firing shots single, and possibly a greater amount of powder is used, but for safety simultaneous shot-firing cannot be compared with it. Consequently, although simultaneous shot-firing does undoubtedly possess some advantages, on the grounds of safety, I do not favour its use. I do not think it is practised to a great extent in modern mines, and in the mine where I am employed simultaneous shot-firing is not favoured, the firing of single shots being the rule.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

[NOTE.—As a general rule we are opposed to the principle of simultaneous shot-firing. If we fire in series there is a possibility of the current not being strong enough to fire the shots, or of one defective detonator preventing the firing of any of them, while if we fire in parallel we cannot tell if all the shots have gone off. It is not to be denied that the firing of several shots at once will often be considerably more effective than the firing of each of these shots singly, and this is especially the case when firing the sumping shots in a sinking pit. In a sinking pit it is furthermore very inconvenient to fire each shot singly, seeing that it is necessary to come to the surface every time a shot is fired.

Taking the question generally, we are of opinion that simultaneous shot-firing should only be allowed in sinking pits for the reasons that if each shot had to be fired separately great delay would be caused, and also that by firing sumping shots simultaneously a much greater amout of work will be done than by firing them singly.—C.C.M.]

F. Hutchinson (*12 marks*).

W. T. Hughes (*8 marks*).

Boiler Pressure.

Q. 12.—*A range of boilers is supplied with water from a natural head by a 3-inch pipe, but the pressure is found to be too low. How would you get an increased pressure?*

A.—To get an increased pressure under the circumstances it would be necessary to employ either a pump or injector, and in this case I should prefer the latter appliance, a common form being that known as Giffard's, which is similar, and indeed is an improved form of jet pump, by which the energy of a jet of steam that comes from the boiler which is fed is made to drive the water inside. It would perhaps be as well to describe the action of the jet pump. (See *Figure 1*). This machine works by means of the tendency of a stream or jet of fluid to carry or drive contiguous particles of fluid along with it. The general nature of its construction is represented in sketch. *A* is the jet pipe by which a sufficient supply of water is brought from an elevated source; *B* is the suction pipe by which another portion of water is drawn from a low level; *C* is the contracted throat of the passage, at or a little behind which is the nozzle of the jet; *D* is the trumpet-mouthed spout in which the jet mingles with the stream from below, carries it forward, and causes a diminution of pressure behind the nozzle, and in the suction pipe sufficient to make the water rise.

There are several types of injectors, some of which use steam from the boilers, and others the exhaust steam from the engine. The latter are, of course, the most economical in working, but

they are only adapted for low pressures. The principle of all injectors is the same, a jet of steam taking the place of the jet of water in the simple jet pump described above. The accompanying sketch shows "Giffard's Injector," the principle of action of which is as follows: The steam enters the branch pipe *A*, and passes through the conical nozzle *B*, at the bottom of which it meets the water, which enters the branch pipe *E*, and is condensed. The vacuum thus formed causes more water to rush into the injector, and this feed water is carried on by the force of the condensed steam jet through the back pressure valve *J*, into the boiler. The velocity of the steam jet is somewhat reduced by imparting a high velocity to this volume of water, but it is not reduced nearly so low as that of a jet of water issuing under the same pressure, and therefore it is capable

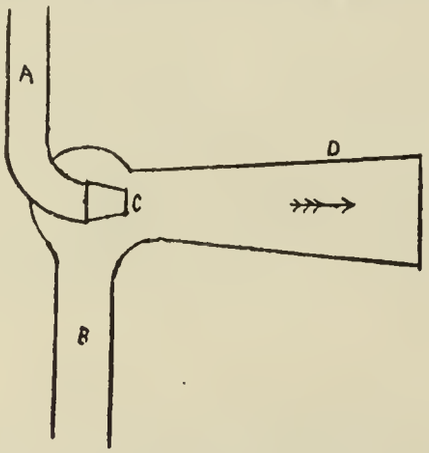


Figure 1, illustrating Question 12.

of overpowering and forcing back the water into the boiler against a pressure greater than its own. The admission steam is regulated by the wheel *D*, which works the conical spindle *C*, and regulates the area of the steam passage. In like manner the mixing cone *F* can be raised or lowered by the wheel *G* to regulate the water feed. To get the best results it is desirable to fix the injector a little below the level of the water supply, but it will work when placed a few feet above, as they will draw water from 2 to 12 feet. For low pressures the water must not be more than 135°F., or for high pressures 105°F.

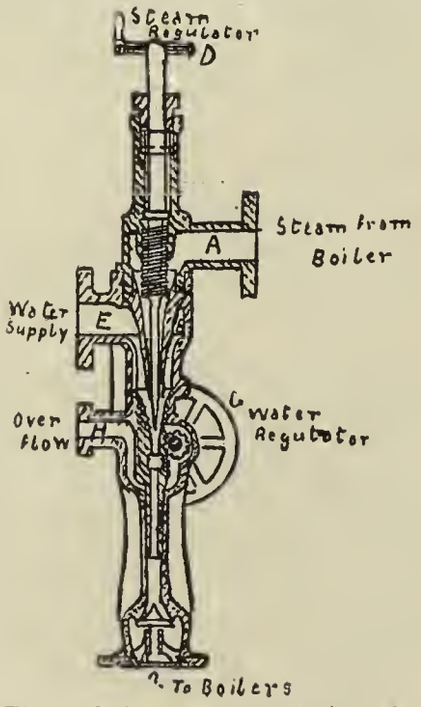


Figure 2, illustrating Question 12.

The ordinary rule for finding the proper sectional area for the narrowest parts of the nozzles is as follows:—

For square inches: $\frac{\text{Cubic feet per hour gross feed water}}{800 \sqrt{\text{pressure in atmosphere}}}$.

For circular inches: $\frac{\text{Cubic feet per hour gross feed water}}{630 \sqrt{\text{pressure in atmosphere}}}$

The expenditure of steam being about 14 times the volume of the water injected.

Indebted to a *Manual of the Steam Engine*, by RANKINE.

FRED HUTCHINSON, 27, Longfield Road, St. Helens Road, Bolton.

[NOTE.—One of our students in answering this question stated that he would change a few of the bottom lengths of 3-inch pipes for 4-inch ones, and so nearly double the pressure. Certainly, the total pressure on the bottom of a 4-inch would be greater than on the bottom of a 3-inch pipe, but the pressure per square inch would not be affected. We should certainly under the circumstances make use of an injector; no doubt an injector supplied by exhaust steam from the engines would be quite sufficient for the purpose.—C.C.M.]

W. Heys (*12 marks*).

GOLD IN COAL.

An interesting feature about the coal mined at Cambria, Wyo., is that it is claimed to be gold-bearing. *Mining Science* points out that some of the coal has contained as much as $2 per ton in gold, and the coal was sold for only $1·50 per ton. When coke made at Cambria was selling for $3·50 per ton, samples were taken from 31 cars during a period of three weeks and assayed. The samples showed an average of $2·46 per ton in gold and $0·28 in silver. The explanation offered for the presence of gold in this coal is that the sands which submerged the old peat bog and now form the roof of the coal bed were derived in part from gold-bearing alluvium. While the sand was being deposited the gold worked down into the underlying bog, and is now found in the coal.

VETERAN MINE INSPECTOR DEAD.

The death took place at his home at Pendleton on Saturday, April 27th, of Mr. Joseph Dickinson, the oldest member of the Manchester Geological and Mining Society. Mr. Dickinson, who had attained the great age of 93 years, was for many years the Government Inspector of Mines for this district, and his experience went back to the early days of Government control for the coalmining industry. Up to the beginning of this year he took an active interest in matters associated with the safe working of the mines, and he never failed to attend the monthly meetings of the society, offering valuable contributions to the discussion on coal dust in the mines and other causes of explosions. The deceased gentleman was one of the four inspectors appointed to carry out the Inspection of Mines Act in 1850. His district comprised the counties of Lancashire, Cheshire, North Wales, Staffordshire, Shropshire, and Worcestershire. Subsequent statutes relating to mines regulations increased the number of inspectors, and Mr. Dickinson continued to hold a prominent position until the working of the age limit compelled his retirement in 1892 after the completion of forty-one years' service. Mr. Dickinson was a Tynesider, and he gained his knowledge of ironworks and coal mines and railways in the North and in Wales, and had been elected a Fellow of the Geological Society of London before entering the Government employ. As an inspector he gleaned much information in Continental mining districts which was made use of by the Government in coal mines legislation and the adoption of rules governing the industry. He was a member of the Royal Commission which in 1871 reported that the coal supplies of this country would not be exhausted for at least two hundred and seventy-six years. He was several times President of the Manchester Geographical Society, and was an honorary member of a long list of engineering associations, mining, civil, and mechanical.

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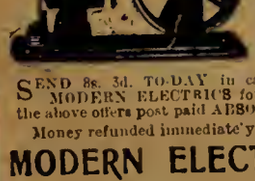

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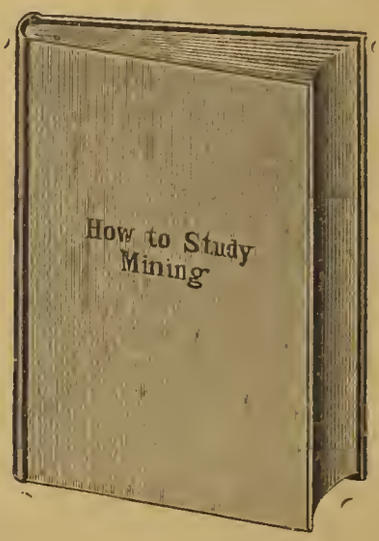

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NEWS AND NOTES.

Coal Exports.

A Board of Trade White Paper shows that the total exports of coal from the United Kingdom during 1911 amounted to 64,599,266 tons, as compared with 62,085,476 in 1910, 63,076,799 in 1909, 62,547,175 in 1908, and 63,600,947 in 1907. Nearly half the coal was exported at prices ranging between 8s. and 11s. per ton. The high quality of the Welsh coals is illustrated by the price figures. Of the grand total Bristol Channel ports exported 25,199,786 tons, or about 40 per cent., but these ports are responsible for practically the whole of the coal exported at prices exceeding 13s., the figures being 19,221,076 tons out of a total of 19,727,291. The total coal exports from Cardiff were 16,127,777 tons. The North-Western ports exported 711,703 tons, and North-Eastern ports 21,716,207 (Newcastle 6,884,611, and South Shields 5,299,752). Humber ports exported 6,264,063 tons, and other English ports 325,376 (London only 2,089). Scotland exported 10,382,311 tons.

Coal Dust Ignition by Electricity.

In view of the increasing importance allotted to electricity in modern mining, Dr. Hugo Spiel, of Vienna, in proposing plans and specifications for the installation and equipment of underground coal dust testing stations, specially points out that the possibility of ignition by electricity must not be lost sight of. Tests conducted by Bedson, Widdas, Holzwarth, Mayer, Engler, and the directors of the Pittsburg testing station prove that in certain circumstances coal dust may be brought to the explosive point by weak electric sparks, and, the author says, there can be no doubt that the strong sparks—sometimes they even develop into small flame arcs—which are frequently produced by the high voltage nowadays often employed in mining may lead to explosions in places of heavy dust aggregation. Dr. Spiel therefore recommends provision at some points of the testing galleries for spark-testing spaces with different voltages.

Rescue and Aid Order, 1912.

The Secretary of State, forwarding a copy of the Order which he has made with regard to the formation and training of rescue brigades and the supply and maintenance of appliances for use in rescue work, says the Order will apply to *all* mines in which coal is worked, except in the case of such small mines as may be exempted under Section 1 of the Order. Any owner applying for such an exemption will be required to show why the organisation of a Central Rescue Station from which his mine can be served is impracticable. The application should be addressed to the Inspector of the District, who will forward it to the Secretary of State. The Order comes into force at once, and it will be necessary, therefore, for each owner to take steps without delay to comply with the requirements of the Order. Reasonable time will be allowed in which to complete the formation of the rescue brigades and to obtain the requisite supply of breathing appliances. It will be observed that certain of the requirements may, in certain circumstances, be discharged by the affiliation of the mine to a Central Rescue Station. The rules specified in Section 8 of the Order will not be required to be submitted to the Inspector or the Home Office for approval. Where oxygen breathing apparatus is used, care must be taken to ensure a high standard of purity in the oxygen used, and supplies, unless guaranteed by the manufacturers, should be tested by analysis. The Secretary of State is advised that it is not practicable entirely to exclude the presence of nitrogen, and that provided the nitrogen present does not exceed 2 per cent., the safety of the users of the apparatus will not be endangered. Oxygen containing a greater amount of nitrogen than 2 per cent., or any other impurity, would become a source of danger and could not be regarded as complying with the requirements of the Order. The following course of training is approved by the Secretary of State for the purposes of Section 3 (*d*) (i. of the Order, and where that course is adopted, no special application for his approval need be made. In cases where no gallery is available, the course of training proposed to be adopted should be submitted to the Inspector of the District. (1) The course of training shall consist of practices with breathing apparatus in a gallery so constructed as to represent the conditions existing in a roadway of a coal mine, and shall extend over three consecutive months. There shall be at least one practice a week. (2) The practices shall be carried out by each brigade as such, *i.e.*, by all the members of the brigade at one and the same time. (3) The first practice shall be carried out in a respirable atmosphere, and subsequent practices in an irrespirable atmosphere. Each practice shall last at least two hours, unless, in the opinion of the Instructor, it is desirable in the interest of safety to curtail the practice in respect of any member of the brigade, or of the brigade as a whole. (4) The practices shall comprise the following operations, or operations of a similar character, in which each member shall take part: (*a*) Building and removing temporary stoppings of stone or brick, and carrying the materials required for the same over a distance of at least 10 yards. (*b*) Removing *debris* in confined spaces, as representing the clearing of a fall of roof. (*c*) Setting timber or other roof supports (*d*) Carrying a dummy body weighing 150lb on a stretcher along the length of the gallery, and through an opening two feet high by three feet wide and four yards long. (5) A record shall be kept of each person undergoing training, and the date and character of each practice attended.

Electric Furnaces.

In his paper on "Improvements in Electric Furnaces and their Application to the Manufacture of Steel," before the Iron and Steel Institute, Dr. Hans Nathusius contrasted the practical value of the various types of furnace used in steel works very much to the detriment of the induction electric furnace. His subject was of special interest to metallurgists, and he showed that recent experience in the manufacture of steel by electric means points to the arc furnace as the most suitable, being less costly and more easy of regulation. The simple arc furnace had certain disadvantages which he pointed out, and these he claimed to have overcome in a new form of circular furnace which he had designed. Several such furnaces have been in service for over two years in two Silesian smelters, and completely satisfactory performances have been made in the refining both of Bessemer steel, charged molten, and on cold metal introduced as scrap along with the ordinary fluxes. The lives of the furnaces have been longer than in usual practice, and heavy repairs to the bottom were never required. The current used in the furnaces was drawn from the local supply of three-phase alternating current, and fed to three separately suspended and mechanically operated carbon electrodes, which are withdrawn when the furnace is tilted. The special feature of the furnace is three bottom electrodes of steel embedded in the hearth, by which heat is supplied to the metal, while the greater heating effect of the arcs is concentrated upon the slag. Comprehensive tables were submitted to show the application of the furnace to various steel works operation in conjunction with basic Bessemer or open-hearth working.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications.

Ventilating a Sinking Shaft.

To the Editor of The Science and Art of Mining.

Sir,—I will be pleased if some reader will give information re the following:—

The upcast shaft of a colliery is to be sunk to a distance of 100 yards. How would you ventilate the same, the upcast being used for winding purposes?

Yours, &c.,

Cymro.

Equations.

To the Editor of The Science and Art of Mining.

Sir,—For the benefit of Learner I am sending a solution of the equation $x + \left\{\frac{x^2}{100}\right\} = 119$.

Removing fractions it becomes

$x^2 + 100x = 11{,}900$.

$x = \frac{1}{2}(-100 \pm \sqrt{100 \times 100 + 4 \times 11{,}900})$.

$x = \frac{1}{2}(-100 \pm \sqrt{57{,}600})$.

$x = \frac{1}{2}(-100 \pm 24)$.

From which $x = 70$ or -170.

Yours, &c.,

Henry Nightingale.

[This problem is fully discussed by Tyke in "Examination (and other) Questions Answered."—Ed.]

Rope Splicing.

To the Editor of The Science and Art of Mining.

Sir,—I see in No. 17, Vol. 22, page 386, that Learner asks how to splice a six-stranded rope into a five-stranded rope. As I have had the same thing to contend with I can give him a good method of splicing the ropes.

First.—Undo the two ends into single strands as long as you please, then thread them into one another, and pull up tight to make the hemps meet in the centre. But you will find that there are two strands together in the six-stranded rope, and no strand between them out of the five-stranded side. Run all the strands away from the centre of the splice, except the one which has none to take its place, that is, one of the strands out of the six-stranded rope. This strand must not be moved from the centre of the splice, but the others must be equally divided up in lengths. Then cut the strands off ready for running into the rope, cutting them short enough to leave four or five inches of hemp in between the tucks; also put twine on the strands to make them the same diameter as the hemp you take out. Then, when running the tucks in, be careful not to take the hemp out any further than the end of tuck. If it is taken out further than this one of the strands from the outside will drop into the centre of the rope and force the end of the tuck out; also, if the strands are not bound with twine this will take place also, and the splice looks very bad when running.

When you get to the single one which you left in the centre of the splice, run it in as if you were running one side of a double tuck in, and leave the hemp in the other side; but be very careful not to move this strand from the centre of the splice, or it will lead you into difficulty with the splice.

I hope this will help Learner out of his difficulties, as I have learned it myself, and find it works satisfactorily. I am sure he will find it will work, and if it does so will be pleased to hear through this valuable paper very shortly.

As regards the handbook I do not know of one, but if Learner gets one he may find it does not contain all the little bits he requires for rope splicing. All rope splicing or different ways of splicing end at the same, only you get them to lay in the rope better when you try some different ways.

Yours, &c.,

A. Butler.

Anthracite.

To the Editor of The Science and Art of Mining.

Sir,—I shall be glad if you will publish in your most valuable and instructive paper the following remarks on Mr. Hey's answer on the origin of anthracite in *The Science and Art of Mining* for May 11th, 1912. He states that there are two principal theories to account for the origin of anthracite. Those given are contact and regional metamorphism. There are no evidences in this country to prove that anthracite is due to any of the theories given. He mentions the "effects of intrusive dykes," and explains "*intrusive dykes*" as "intrusive *volcanic* rocks." The use of the words *intrusive* and *volcanic* rocks have not been thoroughly mastered. Intrusive rocks are subsequently *injected* rocks, *e.g.*, dykes and Plutonic rocks. Volcanic are *extrusive, ejected* contemporaneous lava-flows. Where the nature of the coal has been changed by contact metamorphism, the effects are always local, and there is a large percentage of ash. In discussing the origin of anthracite it is of vital importance to realise the significance in the marked decrease rather than increase in the percentage of ash. The following three analyses by G. vom Rath show the nature of change:—

A, 8·29 %. *B*, 9·73 %. *C*, 45·96 %.

A shows the percentage of ash in the ordinary coal some distance from the intrusive rock; *B* gives the percentage of ash about a foot from the igneous intrusion; and *C* is taken at the contact of the eruptive mass.

South Wales is the only coalfield in Britain where coals are found which are physically and chemically true anthracites, though semi-anthracites are found elsewhere. Here the origin of anthracite cannot be attributed to the effect of contact metamorphism, because the coalfield is destitute of igneous rocks. The only igneous rocks in South Wales are confined to Pembrokeshire, and are of Pre-Carboniferous age, therefore, they could not affect the coals.

For the anthracitisation in South Wales, Mr. Heys conjectures that the effects of the disturbances have been greater in the anthracitic area than in the other part of the field, but De La Beche pointed out that there is no evidence to support this view, and in the areas, particularly in Somerset, the rocks are far more disturbed and contorted than in Pembrokeshire—and yet the coals remain of the bituminous type. To account for the origin of anthracite, it is necessary to change the whole of the fundamental basis of the argument given in the answer. As far as the South Wales coalfield is concerned, the "Peat to Anthracite" theory can be relegated to the limbo of oblivion. The "principal theories" given by Mr. Heys have no geological evidence in this country to prove them. No coal is converted into anthracite in North of England, Leicestershire, or South Staffordshire, where the coal seams are riddled with igneous intrusions; further, the areas where anthracite is found are less disturbed than where bituminous coal occurs. The recent memoir by Mr. A. Strahan gives very valuable information on this subject. After an exhaustive survey of the facts, Mr. Strahan arrives at the conclusion that probably the nature of the vegetation composing the Mother substance determines the type of coal, and that bituminous and anthracitic coals have originated from accumulations quite distinct from one another as regards the kind of plant *debris* in each case. This explains the different types of fuel, which occur in the same seam. The old view of "change from bituminous to true anthracite," by destructive distillation due to internal heat, contact with igneous intrusions, or disturbances and contortions, must give way to the modern view, that the kind of vegetation forming the Mother substance determines the type of coal, and that bituminous and anthracitic coals have different physical and chemical characters, which have originated from differences in the plants which composed the original Mother substance.

Yours, &c.,

John H. Davies.

Ventilation.

To the Editor of The Science and Art of Mining.

SIR,—In books on mining we are told that the pressure that may be expected from a ventilating fan can be ascertained from the following rule :—

Let H = ventilating pressure in height of air column ;
V = speed of fan tips in feet per second ;
g = gravity.

Then $H = V^2 \div 2g$.

On the very same page we are informed that many writers prefer to use $H = V^2 \div g$.

Now, both formulæ cannot be correct.

I would suggest that the readers of *The Science and Art of Mining* should discuss this knotty point with the view of arriving at the truth.

Yours, &c.,

W. G.

To the Editor of The Science and Art of Mining.

SIR,—Being a constant reader of *The Science and Art of Mining*, I notice there is a difference of opinion existing amongst mining students as regards the speed of the fan, if the covering on the top of the upcast shaft is removed. Well, I consider it my duty as a mining student to give a case in point. A friend of mine was looking after a single cylinder horizontal engine which was driving a Schiele fan, the power transmitted to the fan by a large leather belt. In the course of the shift he noticed all at once an appreciable decrease in the speed of the engine, and also the belt began to creak. He immediately turned his attention towards the steam gauge, but to his surprise he found the reading to be normal (60lb.) He then opened the throttle valve to the extreme, but with no effect ; after inspecting the engine he turned to the W.G., which, to his surprise, the water in both glasses was just about level. He then went into the fan chamber, but it was day light inside ; the roof had blown away, and this explained the phenomenon. The shaft was only used for ventilating purposes. The usual speed of the engine was 60 revolutions per minute with the above steam pressure, but in this case he could not get the engine to go beyond 40 revolutions per minute.

I should also state that the belt was almost wrenched apart by the increased load, and was of no further use. The workmen had to come out of the mine because the current was practically dormant.

Yours, &c.,

PORTHITE.

To the Editor of The Science and Art of Mining.

SIR,—"What would happen if the doors on the top of the upcast were opened ? Would the fan slow down, stop, or increase in speed ?" are the questions discussed by Mr. KILPATRICK. The answers which he gives are, in my opinion, quite correct.

Experiment and theory both show that the fan would either slow down or stop altogether if driven by an ungoverned engine.

Long ago, before I knew there was such a science as that of ventilation, I discovered this truth. One day I was amusing myself at a farm with the hand fanners for winnowing the grain. I may explain that this machine is just a fan of the Guibal type running in a casing. It receives its air at the sides, and discharges it at the circumference into a sort of rude chimney. While making the fan revolve I got another boy to close the inlets for air. The effect was not what I expected. I anticipated that the blocking up of the air passages would have the same effect as a stopper in a tobacco pipe. I expected to be brought to a standstill. I was mistaken. Whenever the inlet was closed my burden was lessened. Whenever the inlets were opened my burden was increased.

Now, why should a fan slow down when the doors on the top of the upcast are thrown open ? In answering this question I will assume that the fan is a Waddle, and that the velocity of its rim is V feet per second. A Waddle fan is so constructed that the radial velocity of the air passing through it is uniform. But as the air passes through it there is imparted to the air a tangential velocity which is zero at the inner part of the vane, but which is increased to V feet per second at the periphery, where it is discharged, assuming that the radial velocity of the air is kept constant while passing along the vanes there will be no change of momentum whatever, and consequently no reaction required from the blades. We may, therefore, leave it out of consideration. Indeed, all that we require a fan to do is to impart to the air passing through it a tangential velocity.

Let M = mass of air in lb. passing per second, then the force that the fan must exert = MV poundals or $\frac{MV}{g}$ lb.

This result shows that the force required to drive a fan is in proportion to the quantity or weight of air passing through it. To allow more air to pass through the fan remove all obstacles to the flow of the air, that is to say, reduce the friction or drag of the mine. This can be done by enlarging the air-ways or by shortening the air-ways, or by opening the doors at the top of the upcast.

To illustrate the theory I have been setting forth I will take this example :—

If 125,000 cubic feet of air be circulated per minute through an air-way 5 feet high and 5 feet wide, and 6,500 feet long, by a fan when making 120 revolutions per minute, what quantity would be circulated per minute if the doors at the top of the upcast were thrown open. The fan is 14 feet in diameter, and it also makes 120 revolutions per minute when the doors at the top of the upcast are open.

Diameter of fan = 14 feet.
Circumference = 44 feet.
Velocity of blades per minute = $44 \times 120 = 5{,}280$ feet.
Velocity per second = 88.
Theoretical W.G. = $\cdot00045V^2 = \cdot00045 \times 88 \times 88 = 3{\cdot}48$ inches, say 3·5 inches.

We see it requires a W.G. of 3·5 inches to force the air through air-ways and through the fan.

$$\text{W.G. for air-ways} = \frac{KSLV^2}{5{\cdot}2A}.$$

$$\text{W.G. of air-ways} = \frac{\cdot01 \times 130000 \times \cdot5 \times \cdot5}{5{\cdot}2 \times 25} = 2\tfrac{1}{2} \text{ inches.}$$

W.G. to force air through fan = 3·5 — 2·5 = 1.

The question may now be stated thus :—

If 125,000 cubic feet of air is forced through a fan with a W.G. of 1 inch, what quantity will be forced through with a W.G. of 3·5 inches.

N.B.—In both cases the W.G. is 3·5 inches for the number of revolutions in both cases is 120.

Quantity with 1 inch = 125,000 cubic feet.
Quantity with 3·5 inches = $125{,}000 \times \sqrt{3{\cdot}5} = 237{,}500$ cubic feet.

H.P. of fan when receiving its air from mine

$$= \frac{125000 \times 3{\cdot}5 \times 5{\cdot}2}{33000} = 68{\cdot}9.$$

H.P. of fan when receiving its air through doors at top of upcast

$$\frac{237500 \times 3{\cdot}5 \times 5{\cdot}2}{33000} = 130{\cdot}9.$$

Yours, &c.,

W. G.

Examination Results.

The following is a list, communicated by the Home Office, of the successful candidates at the Examination held in the Midland and Southern District on the 23rd, 24th, and 25th April, 1912, to whom Certificates of Competency as Managers or Under-Managers of Mines have been granted under the Coal Mines Regulation Act, 1887 : FIRST CLASS (*Managers*) : Henry Edmund Blackburne Daniell, Gordon Gregory, John George Jones, Arthur William Gray, George Harold Riley, Harold Hyde Ridsdale, Henry Jameson Main, Elijah Rowley. SECOND CLASS (*Under-Managers*) : Wilfred Victor Holdam, James Jones, Thomas Potts, Thomas Smith, George Frederick Smith, Arthur Hurley, Thomas Newnes, William Rees, Arthur Emery Booth, Arthur Saxton, William Percival.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen. Deputies, or Examiners.]

By M.E.

No. 8.—Explosions and Coal Dust.

That the presence of gas alone is insufficient to explain many explosions is further supported by the following observations :—

1.—The distances traversed by some explosions are enormous ; some extending for miles. It is difficult to account for sufficient gas to produce an explosive mixture throughout such lengths of roadway.

2.—There is usually no evidence of alarm on the part of the workmen. If an explosive gas mixture had been in existence previous to the explosion, its action on the flames of the lamps would have warned the workmen, who would have adopted precautionary measures.

3.—The force of an explosion, as a rule, acts from the main roadways *towards* the gobs and working faces. As there is a greater probability of gas existing in these latter, on the assumption of exploding gas, the predominating signs of force should be *from* the gobs and faces towards the roadways.

Conclusions based on the evidence of force should, however, be accepted with caution owing to the complexity of the action.

4.—When a gas explosion occurs the flame must be limited to those parts of the mine containing an explosive mixture whereas, in most large explosions, it travels the main haulage roads—usually the intake air roads—in which it is highly improbable that gas could exist ; and, moreover, the length of these roads and the extent of the explosion usually coincide. It is highly significant that an explosion seldom enters a return air-way unless it is used as a haulage road, in which case it is usually dry and dusty.

5.—In a mine charged with an explosive gas mixture a branch roadway would have a similar atmosphere to the main roadway of which it is a branch, and an explosive wave would pass with equal force through each. In many cases an explosion is selective at a junction, sparing one or more roadways, but passing through the others, the path apparently depending on the dust.

6.—In large explosions no great force is, as a rule, exhibited for some distance on either side of the point of ignition, and the violence increases with the distance from this point. In a pure gas explosion the greatest force is usually near the point of ignition, and the violence diminishes with the distance.

7.—Many large explosions have occurred in mines normally free from fire-damp, and worked with open lights.

8.—All large explosions have occurred in mines that are known to have been dry and dusty, and have frequently coincided with the firing of shots *in main intake air-ways* in which gas could not exist in any but the smallest, and, in themselves, perfectly harmless quantities.

Experimental Evidence.—Though the history of many explosions suggests that coal dust is the chief agent in the *propagation* of an explosion through a mine, and an important factor in the *initiation* of such, it is necessary, in order to base mining practice on a firm foundation, to test the accuracy of this hypothesis by an appeal to established facts.

The evidence available for consideration may roughly be divided into two classes—that obtained from the mine after explosion, and that obtained by experimental research.

Of the two classes of evidence the latter is the more valuable, as, by the scientific methods adopted, each factor entering into the problem can be separated from the rest, and subjected to a detailed examination, without the confusion that must necessarily arise in an actual mine explosion.

The experiments of Professor Galloway in 1875 were probably the earliest from which definite conclusions could be drawn. In these it was found that a mixture of air and fire-damp which could not be ignited with a naked light, developed a tendency to explosion when coal dust was added. In these experiments the gas, air, and dust were intimately mixed in a suitable apparatus, and caused to pass in a current on to an open flame which produced ignition. It is apparent that if the addition of coal dust has the effect of converting an otherwise inexplosive gas mixture into an explosive mixture, the dust itself must be considered dangerous.

A few years later further experiments were conducted by Mr. Galloway, with an apparatus consisting essentially of a wooden gallery 126 feet long, and 4 square feet in section, at one end of which was fitted an explosion chamber, 6 feet long and 2 feet in diameter.

Two series of experiments were conducted. In the first series coal dust was not used, and the effects produced with purely the effects of exploding gas. Various fire-damp mixtures were ignited in the explosive chamber. The flame of the explosion was allowed to freely extend itself in the dustless wooden gallery, and the length of flame produced was carefully measured. As the result of numerous experiments the average length of flame produced in these circumstances was *about 13 feet.*

In the second series, dry coal dust was laid on the floor of the gallery and on shelves fitted to its sides. *No gas was permitted to pass through the gallery and mix with the air and dust.* Explosive gas mixtures were put into the explosion chamber and fired, as in the first series. The flame, instead of being limited to a distance of 13 feet, now extended along the gallery, raising from the floor and shelves and carrying before it a cloud of fine coal dust into which it shot as it emerged from the mouth of the gallery.

In both series of experiments the initial explosions were due to the ignition of similar mixtures, but the effects produced were different, the difference obviously being due to the presence of the coal dust.

The first experiment with coal dust in an underground mine was made by Mr. Henry (now Sir Henry) Hall, at St. Helens, Lancashire, in 1876.

An adit level 45 yards long was lightly strewn throughout its length with fine coal dust. A shot of gunpowder was fired at the face of the level, which, igniting the dust, produced an explosion of a violent character. This travelled the full length of the level, and ceased only when the train of dust was consumed. So far as could be ascertained no gas was present in the adit.

In 1890, on behalf of the Royal Commission on Coal Dust, Mr. Hall conducted an elaborate series of experiments on a practical scale.

The first series was carried out in a disused pit shaft near Ormskirk. The shaft was 50 yards deep, and 7 feet in diameter. A cannon 2½ feet long, with a bore of 2 inches, was placed at the bottom of the shaft pointing directly upwards. The air in the shaft was then saturated with fine coal dust, which was thrown down from the top, and the cannon fired by electricity with the dust in suspension in the shaft.

In many cases explosions of more or less violence were produced.

During the same year further experiments of the same kind were conducted by Mr. Hall, at Haydock.

The last experiment he describes as follows :—

"Dust was ignited, followed by a continuous roar and a rush of flame, completely filling the pit mouth and ascending 60 feet into the air. This was the most violent explosion since the commencement of the experiments. It is difficult for any one who did not witness this experiment to realise the extent of the explosion. The flame continued to issue from the pit for five or six seconds followed by dense smoke. The violence carried away some of the woodwork 37 feet above the pit mouth."

In each experiment the dust was ignited by a shot of gunpowder, blown out from the mouth of the cannon, the charge varying from threequarters to about four pounds.

As the air to which the coal dust was added *was totally free from fire-damp,* the danger of shot-firing, in circumstances in which there is even a remote possibility of the creation of a dust cloud in the air at the time of firing, even if it is an impossibility for fire-damp to be present, should need no further demonstration.

Unfortunately, the human mind dearly loves its prejudices ; and while the evidence provided by the foregoing experiments was quite conclusive as to explosibility of dust and air, it has been considered necessary to have further experiments on a larger scale, and of a more spectacular nature, to bring conviction to the mind of the ordinary practical man, accustomed to dry and dusty roadways.

A Committee was appointed by the Mining Association of Great Britain to conduct a series of experiments at Altofts during 1908 and 1909. These were on an elaborate scale, and a valuable report of the results obtained was published in 1910.

It is outside the scope of this article to give a detailed description of the apparatus used and the results obtained, but reference may be made to an exceedingly interesting experiment (No. 25) in which so much violence was produced that it cannot fail to be impressive.

The gallery used was 7 feet 6 inches in diameter, and built of $\frac{7}{16}$-inch boiler plating, capable of resisting a static pressure of about 160lb. per square inch. This was arranged to represent an underground roadway, being timbered with bars and fitted with a full-sized tub road. 86 timber sets were fixed in the intake. The length of the intake was 684 feet, and of the return 295 feet; the sectional areas being 41 and 28 square feet respectively. A quantity of 53,000 cubic feet of air per min. was passed through the intake at a velocity of 1,292 feet per minute.

Fine coal dust was spread for a distance of 450 feet from the intake end of the gallery, and the rate of 1lb. per linear foot, equal to 0·39 ounce per cubic foot of space.

Ignition was produced by a small cannon, which was charged with 24 ounces of ordinary blasting gunpowder, stemmed with 8 inches of clay, and placed 360 feet from the mouth of the gallery.

The dust was raised by a smaller cannon, and the above charge of powder fired into the cloud produced, resulting in a very violent explosion which shot out a great distance from the intake end of the tube.

The force developed was terrific. Three boiler shells forming the intake end of the gallery were completely shattered, and pieces varying from 30lb. to 1,500lb. were scattered over the adjacent fields. One piece, weighing 401b., was blown nearly a quarter of a mile, and some pieces were estimated to rise to a height of about 500 feet.

Gas was entirely absent, and the force developed was solely due to the exploding mixture of coal dust and air.

Varieties of Coal Dust.—It was recognised by early experimenters that all coal dusts were not equally dangerous, the differences in explosibility being chiefly due to differences in the composition, structure, and fineness of the particles of dust.

Coal is an extremely complex aggregate of solid carbonaceous matter and volatile matter, the latter being retained in the pores of the former, or held in loose combination with it.

This volatile matter is more or less easily driven off by the application of external heat, and it is found by experiment that in some way or other the explosibility of a coal dust is somewhat dependent on the amount of volatile matter present, the danger increasing with the percentage.

While it is claimed by some experimenters that a dust containing less than about 10 per cent. of combustible volatile matter is comparatively safe, such statements must be considered in connection with the *fineness* of the dust.

There are many instances on record of the explosibility of dusts containing no inflammable volatile matter, and the Altofts experiment (No. 106) showed that even powdered wood charcoal is explosive on ignition, if freely suspended in ordinary air.

That the fineness of the dust is a deciding factor has been clearly proved by experiment. Professor Bedson has shown that as the fineness of division of a coal dust of given composition is increased the amount of heat necessary to ignite the dust is reduced; and Professor Cadman has effectively demonstrated the possibility of ignition at *a candle flame*, if the dust is fine enough; and that the violence increases with the fineness of the dust.

The dust which is most dangerous is, as a rule, that which settles on the roof and sides of a roadway after floating in the air current for some time. That this is much finer than road dust is shown by the following figures, taken from the British Coal Dust Report, referring to the main haulage roadway in the Silkstone Pit, and which may be considered representative:—

	Dust from Floor.	*Dust from Sides 3ft. above Floor.*	*Dust from Bar Tops.*
	%	%	%
Remaining on 100 mesh..	47·3	6·2	1·7
Through 100 on 150 ..	17·1	4·1	1·3
Through 150 on 200 ..	1·9	0·1	0·8
Through 200 on 240 ..	6·7	6·9	5·1
Through 240 and finer ..	27·0	82·7	91·0

The mesh number indicates the number of openings per linear inch so that the 240 mesh contains 57,600 openings per square inch.

The extreme fineness of this latter dust, and, compared with its bulk, the large surface each particle presents to the oxygen when suspended in air, explain the extreme rapidity with which it is consumed.

In an explosive mixture of fire-damp and air, each small particle of gas is intimately in contact with a particle of oxygen, and interminglied with it. On ignition, each atom of carbon and hydrogen in the particle of fire-damp is attacked by its neighbouring oxygen atoms with extreme activity, giving rise thereby to the well-known explosive effects.

When *fine*, pure coal dust particles are suspended in the air, in explosive quantity, each particle is enclosed in an envelope of air. It is, therefore, intimately in contact with oxygen, and such arrangement of dust and air may be considered to be a coarse gas mixture. On ignition, the oxygen is quite as active as in a pure gas explosion, and attacks each atom of carbon and hydrogen in the volatile constituents of the dust particle, and also each atom of its solid carbonaceous substance. Oxygen is no respecter of circumstances, and produces equally disastrous effects whether the carbon with which it combines is obtained from fire-damp, or from a coal dust particle, provided it can obtain such with equal facility from each.

In the combustion of the very finest particles of dust it is probable that they are instantly and directly consumed, the temperature due to the combustion of each particle igniting the neighbouring particle and so transmitting flame through the mixture with extreme rapidity and explosive violence.

For all but the finest and purest particles it is probable that combustion is complex. The amount of ash in the dust, the ratio of volatile matter to fixed carbon, the intimacy of oxygen to the molecules of each particle, and of particle to particle, cannot but affect the action; and, as the temperature necessary to distill the volatile matter is considerably lower than that necessary to produce incandescence in a carbon particle, and consequently flame, it would appear that there is a possibility of a two-fold action—the volatile matter being driven off from the dust particle by its rising temperature, to be immediately ignited by the direct combustion of the carbon.

The period of time separating these two effects is so infinitely small that, in many cases, they may be considered as being simultaneous. Where the coal dust is relatively coarse and somewhat impure, the probabilities are that the action may be arrested, the volatile matters being expelled and exploded; whereas the solid carbon may be only partially consumed, and left behind as coked dust.

Owing to the variety of individual dust particles in any dust mixture, it is not probable that any single theory of combustion can include all possible types of action; hence, such can be only partially true and of limited application. Fortunately for practical purposes, a theory, complete in every detail, is not essential in order to secure safety against a demonstrated danger. While there is still much that is uncertain regarding the manner of its explosibility, that coal dust *is* explosive, when suspended in air, has been demonstrated beyond the possibility of doubt.

Those wishing a more detailed knowledge of the facts of this subject are referred to the early work of Professor Galloway; the Second Report of the Royal Commission on Coal Dust in Mines (price 3d.); the Abstracts of the Reports of the recent American, French, and Austrian coal dust experiments, published by the *Colliery Guardian* Co., Ltd. (price 1s. each); the Report of the Committee of the Mining Association of Great Britain on the Altofts Experiments; and numerous papers in the Transactions of the Institute of Mining Engineers.

A valuable record of the personal experiences of Messrs. W. N. and J. B. Atkinson, H.M. Inspectors of Mines, has been published under the title *Explosions in Coal Mines*.

Honour in trade is of more real importance than its assets.

In some business transactions it is a maxim, "Pay for the rabbit and get the skin."

In making a fresh start in anything it is often the case that the newly hatched chicken carries some of the old egg shell on its pin-feathers.

SPONTANEOUS COMBUSTION IN COAL MINES.

In concluding his report on the explosion at the Jamage pit of the Bignall Hill Colliery, Mr. R. A. S. Redmayne (H.M. Chief Inspector of Mines) contributes the following: "Note on the Cause of Spontaneous Combustion in Coal Mines, and Methods of Dealing with it."

Districts in which Gob-Fires Occur.

The occurrence of gob-fires, or the spontaneous ignition of coal or other highly carbonaceous matter in the gobs (goaves, or wastes) of coal mines, has been an accompaniment of coal-mining in certain districts for very many years. Usually, these fires are restricted to the wastes or abandoned areas or the pillar workings of the mines, but in some coal-mining districts, although on rare occasions, they occur in the solid coal on the road sides. Hamstead colliery, in South Staffordshire, is a notable instance of this. In South Staffordshire and Warwickshire, though they have always proved a troublesome feature in mining operations, gob-fires have not proved such hazardous occurrences as in North Staffordshire, where, owing to the existence in the mine of fire-damp, the danger attending them is greatly enhanced.

Gob-fires occur occasionally in other coalfields. In Yorkshire, though they occur in several seams, they are comparatively rare in the really gassy seams—except in the Barnsley Bed in the Doncaster district, in which district a very considerable development of the Yorkshire coalfield is now taking place. Gob-fires are also liable to occur in the following other districts, though not to the same extent as in those already enumerated—viz., Fifeshire, Midlothian, Lanarkshire, Sutherland, Shropshire, Derbyshire, and North Wales.

The Cause of Spontaneous Combustion.*

Coal occludes gases and at the same time absorbs oxygen from the air, the rate of absorption being different in respect of different classes of coal. Thus, for instance, a Northumbrian steam coal does not absorb oxygen to anything like the same extent as some Staffordshire and Warwickshire coals, the difference in this respect being accounted for by physical as well as chemical peculiarities, and spontaneous combustion is all but unknown in the mines of Northumberland, whereas in the mines of Staffordshire and Warwickshire such fires are of very common occurrence.

It used to be supposed that spontaneous combustion was the resultant of the heat due to the oxidation of the pyrites in the coal, the sulphide being coverted into the sulphate, but this has been shown to be false. That the pyrites, especially if very finely disseminated throughout the coal, is a *contributory* cause, is, no doubt, true, the manner of the occurrence of the pyrites being more important than its amount. The chief cause is, however, the absorption of oxygen by the coal, the carbon and hydrogen of the latter being attacked by oxygen.

The following quotation from the report of the New South Wales Royal Commission (page 3) on the cause of the dangers to which vessels carrying coal are said to be peculiarly liable, and the best means that can be adopted for removing or lessening the same, issued in 1897, may be reproduced as confirming my statement as to the cause of spontaneous combustion:—"The following theory of the spontaneous heating of coal appears to us to be well established. Coal naturally absorbs oxygen from the air, and undergoes a process of slow combustion. As this process goes on heat is developed, and the temperature of the coal tends to rise. The activity with which oxygen is absorbed increases as the temperature rises. It appears, therefore, that the conditions necessary for the spontaneous heating of the coal are:—(1) A sufficient supply of oxygen; (2) prevention of the escape of the heat generated. These two conditions are more or less incompatible. Whether the coal heats or not depends upon whether the heat can or cannot escape as fast as it is generated. Since heat passes away more rapidly (other things being equal) the hotter the coal, whilst the supply of air for promoting combustion is conditioned by other circumstances, it often happens that the temperature of a heap of coal will rise to a certain point which it will not pass. If a heap of coal is prevented from coming in contact with air, no action will occur, and no heat will be developed. On the other hand, if the air supply be so free as to carry away the heat generated at a sufficient rate again, no heating will take place."

At a given temperature the rate of absorption will depend on the ratio of the surface of the coal to its volume. Thus, other things being equal, the more divided the coal the more rapidly will it absorb oxygen. On the other hand, the coal cannot absorb oxygen unless the oxygen is there to be absorbed, and when the coal is in very small dust the rate at which the air can penetrate the heap is only small. It, therefore, appears that when the coal is in large pieces it will only absorb oxygen slowly, because of the comparatively restricted area of surface which it exposes; while if the coal is in very fine powder the air will not be able to penetrate the mass with much freedom. There must, therefore, be a certain size of coal at which the rate of absorption will be a maximum. Such an effect was observed by Fayol* (*Etudes sur l'Alteration et la Combustion spontanée de la Houille exposé a l'Air, Appendix DD, page* 73), who shows that small coal in heaps mixed with coal dust offers the most favourable conditions for heating; a conclusion which is in accordance with what has been observed in practice, for, when coal becomes crushed or is naturally in a finely divided state, it is much more liable to spontaneous heating. If, added to this peculiar physical structure, there is the presence of pyrites in *a very fine state of division*, there can be no doubt that the latter exercises a very important bearing in respect of setting up the initial heating and rendering the absorption of the oxygen more rapid in consequence of its disintegrating action. Moisture in the air would seem to play little or no part in the heating of the coal.†

The Combatting of Gob-Fires.

1.—When heating has once broken out in the workings of a mine the method of combatting the same is generally as follows:—(*a*) If it occurs in the solid coal or on a road side, by following along the fractures and loading out all the heating coal. These places are sometimes kept open and ventilated, and thereby kept cool, and sometimes packed very tightly with sand or ashes and dammed off. It is considered necessary in some cases to put in good arches in the roadway, sometimes for a considerable length, the same being kept air-tight by plastering or claying the brickwork. (*b*) If heating occurs in the gob or goaf and the same is accessible, loading and sending out the heated material, and filling the excavation tightly with incombustible material after cooling of the surroundings. (*c*) If the fire has actually broken out and the ignited material cannot be removed, or a fire may be suspected and cannot be reached, damming off the area so as to prevent, as far as possible, all access of air.

2.—With regard to the prevention of heating in the solid coal:—The manner of laying out the mine often constitutes the determining factor. When fire occurs in the solid it generally

* A considerable amount of information is available on the subject of spontaneous combustion of coal. Inquirers into the matter may be referred to:—(1). The Report of the Royal Commission on "Spontaneous Combustion of Coal in Ships." Issued 1876. (2). Board of Trade (Marine) No. 110, Report on S.S. "Walter H. Wilson," by Richard Threlfall, F.R.S. (3). Report of the New South Wales Royal Commission on the causes of the danger to which vessels carrying coal are said to be peculiarly liable, and as to the best means that can be adopted for removing or lessening the same. Issued 1897. (4). Report of a second Royal Commission appointed by the New South Wales Government. Issued 1898.

* M. Henri Fayol, Engineer-Director of the collieries of Commentry and Montvieg, whose important work on the subject was published in 1879. It is contained in the "*Bulletin de la Soc ete de l'Industrie Minerale*" *2nd Series*, Volume 8.

† In an interesting paper by Messrs. H. C. Porter and F. R. Orvitz recently published in the "Journal of Industrial and Engineering Chemistry" an account is given of an investigation by the United States Bureau of Mines into the deterioration and spontaneous heating of coal in storage. The observations of the Bureau are to the effect that the presence of moisture does not promote spontaneous heating, and sulphur has been shown in most instances to have exerted very little influence in this direction, for in a number of actual cases samples of coal which have become heated spontaneously were analysed for the total sulphur and for sulphates, with the result that in no case was the unoxidised sulphur less than 75 per cent. of the average total sulphur in the original. That is to say that not more than one quarter of the total sulphur had entered into any heat-producing reaction. Freshly-mined coal and even fresh surfaces exposed by crushing lump coal exhibit a remarkable avidity for oxygen, but after a time become coated with oxidised material so that the action of the air on the coal becomes less vigorous. Both Dr. E. Richters (Chemist in the Mining School of Waldenburg) and Fayol have demonstrated that damp coal absorbs oxygen less rapidly than dry coal.

originates in fissures. These fissures are formed by pressure; consequently, any attempts to prevent crush naturally tend to prevent fire.

3.—Speaking generally, when fires occur in the solid they occur either:—(*a*) At or near the edge of the shaft pillar in long wall workings in thin seams. (*b*) At stoppings built between main intakes and returns. (*c*) In pillars or narrow ribs of coal. (*d*) In coal between roads that are close together. In all these cases a certain amount of crushing has taken place, and sufficient air is permitted to enter into the coal to allow oxidation and heating to take place, while there is insufficient "through" ventilation to carry off the heat.

With regard to (*a*): It follows that if the goaf is packed solid (*e.g.*, is packed by hydraulic stowage), air will not travel along the goaf edge of the pillars, neither would there be any fractures of importance in the coal near the shaft edge. (*b*) Permanent stoppings of this kind are often made too thin. With a coal roof or a roof of soft material fractures are sure to ensue as the result of pressure, and, under these conditions, if the coal is liable to spontaneous combustion, spontaneous combustion is the more certain to break out. If these stoppings are made much thicker and the brickwork has a cushion of softer material above it, such an arrangement would tend to solve the difficulty. (*c*) The great advantage of hydraulic stowage is evident in this connection, as it would obviate the necessity of ribs and pillars of coal left for the support of the roof in "square work." The only ribs that would have to be left would be those separating district from district. (*d*) There is no necessity to drive roads in such close proximity as to cause undue fracturing of the coal, but so much trouble has resulted in some cases from bad management in this respect that it claims attention.

Finally, wherever the hydraulic system of stowing the goaf cannot be adopted, the following precautions should be taken with a view to prevent gob-fires:—(1) The extraction as far as possible, of the whole of the coal, even though it be of an inferior quality. (2) The withdrawal of timber, as far as practicable from the goaf, for timber is more easily ignited than the coal. As Mr. Pickering put it, "it (timber) does not cause the heating, but supplies the tinder." If timber is left in the goaf it prevents the regular subsidence of the roof, and tends to leave open spaces, thus facilitating oxidation of material which would otherwise have been covered. (3) The goaves should be packed as tightly as possible. (4) Gate-road packs should be made as wide as possible, and well and solidly built.

STEAM ENGINES FOR ROLLING MILLS.

At the meeting of the Iron and Steel Institute, "Steam Engines for Driving Reversing Rolling Mills" were described by Mr. J. W. Hall, who pointed out the very severe duty such engines were called upon to perform. To drive the rolls fast enough to finish long lengths at a single heat the pistons must run at the highest rate possible, and to attain this speed promptly there should be a sufficient reserve of power to impart to the crank shaft immediately after starting a twist about twice as great as that needed to run the engines up to full speed, at which they will develop close upon 10,000 horse-power. The engine needs to be under such perfect control that it can be kept creeping round until the rolls bite the piece to be treated, and it must stop instantly when the piece leaves the rolls, and must reverse at once to take it back again. To ensure promptitude in starting, stopping, and reversing the revolving weights must be low and the steam pressure high, and yet the reciprocating masses must be light, or their weight will produce dangerous shocks. The only objection to the simple reversing engine is its high steam consumption, as it is not advisable to exhaust direct to a condenser; but this difficulty is got over by the use of an exhaust steam turbine, which is most efficient at low pressures, whilst the piston engine is most efficient at high pressures. Indicator diagrams were reproduced to show the effect of different cut-offs upon two and three-cylinder engines, and from a consideration of their defects the author proposed reducing the capacity of the cylinders, but by increasing their number to five the starting effort could be increased and full boiler pressure utilised later in the run, with a saving of steam both at commencement and finish. The first cost of the five smaller engines would also be less than three large ones, and the spare parts to be kept in stock in case of a breakdown would be reduced by about one-half.

POSSIBILITIES OF CHINESE COALFIELDS.

The Manchester Geological and Mining Society met on the 14th inst., with Mr. G. B. Harrison, president, in the chair. The meeting passed a vote of condolence with the family of the late Mr. Joseph Dickinson, who had been described as the "grand old man of the mining world," and who died on April 27th. Mr. George S. Caldwell, of Westhoughton, read a paper on the Chinese coalfields. Many coalfields in China, he said, were worked by natives and foreigners. All the various kinds of coal were represented in one or another of the various districts. The province of Shansi was nearly all one large coalfield, the estimated quantity of coal in this province being six hundred and thirty thousand millions of tons, "or many times the quantity of ungotten coal in Great Britain." Special attention was directed to the Lia New Ho coalfield, in the province of Honan. During recent years boring had been carried out in a thorough and systematic manner by Europeans under European management, and the coalfield had been proved for many square miles, with seams of coal varying from 10 to 40 feet in thickness. The sinking was not such a formidable operation as it was in this country, there being no very hard strata to pierce. The water was the real obstacle, and this was encountered in very large volumes. "That a system of ventilation was necessary in the mine," Mr. Caldwell went on, "was one of the most difficult things to impress upon the Chinese mind. Separation doors and brattice cloths were erected under the instruction of a European, but when he was absent the door would be propped open, or the brattice cloths nailed on one side, or torn down, because the workmen thought that they interfered with the drawing of coal, or with the men shouting to one another. They also could not see the approach of a deputy. Another solution lay in the fact that often the missing brattice cloths had been converted into wearing apparel. . . . It is fortunate that no gas has been found in these mines, because the Chinaman likes to indulge in a short but very frequent smoke with a pipe made from a short piece of bamboo, and if there are no lamps or torches he uses his flint and steel to light up. If it were necessary to prohibit smoking in the mines some very efficient system would have to be adopted to overcome their extreme craftiness, and it would be necessary to make them strip on entering the mine and use clothes provided for them without pockets. . . . The Chinese are a hard-working and industrious people, not difficult to supervise, and very docile, quick to pick up new methods and adapt themselves to European ways, but they are very careless about their own safety, which they seem to treat with contempt. One of their greatest failings is to dose off to sleep at all hours and in all sorts of positions. Many lives have been lost through the pump attendants dozing while attending sinking pumps and falling down the shafts. In some mines the colliers go down for two or three days at a stretch, for the mere fact of winding workmen up and down the shaft each shift would interfere seriously with the output. No Coal Mines Regulation Acts exist, and winding is continued day and night, including Sundays, which are not days of rest. Coal turning is only suspended by some accident, or when the stock of coal on the surface has absorbed all the available capital. . . . Proposals were made in one case to take the railway alongside the mines, but as this would interfere with the employment of barrow coolies the matter was promptly dropped." "The difficulties of race," Mr. Caldwell added, "will quickly disappear when the large numbers of the present generation have completed their education on Western methods, and are able to appreciate the necessity of working hand in hand with foreign enterprise for the development of their rich country and will bring out the qualities which have been lying dormant for centuries in administration, engineering, and all other branches of science which lead a country into the van of progressive nations where the greatest good is spread over the greatest number."

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q. *Find the value of* x *when* $x + \left\{\frac{x^2}{100}\right\} = 119.$

(*Submitted by* LEARNER).

A.—The problem here submitted is known as an adfected quadratic equation, *i.e.*, a quadratic in which the unknown quantity occurs both as a square and as a first power. In solving any quadratic equation, we have to ascertain the values of x, the unknown quantity generally, which will satisfy the given equation. Since x is the square root of x^2, it is obvious that to solve a quadratic equation it is necessary to so simplify and arrange each side of the equation as to render it possible to take the square root of each side. For example, suppose it is required to solve $3x^2 = 300$.

It is not possible to get the square root of either side of this equation; but, it will be seen, if each side be divided by 3, the equation retains the same value, and becomes $x^2 = 100$.

Now x^2 is the square of $\pm x$, *i.e.*, of either $+x$ or $-x$; and 100 is the square of ± 10; therefore $\pm x = \pm 10$.

To those students who do not possess a good knowledge of algebra, this becomes interesting and extremely important. It will be seen that as solutions of the equation $x^2 = 100$, one may get $+x = +10$, $+x = -10$, $-x = +10$, or $-x = -10$. By the *Law of Signs*, however, *like signs give* $+$, *and unlike signs give* $-$. Therefore, of these solutions, $+x = +10$ is precisely the same as $-x = -10$; again, $+x = -10$ is the same as saying $-x = +10$. Hence in the above we get two definite solutions, viz., $x = +10$ and $x = -10$; and these solutions may be written with the double sign, thus:—

$$x = \pm 10.$$

Now taking the quadratic equation submitted in the question and simplifying it by removing the fraction, we have—

$$x + \left\{\frac{x^2}{100}\right\} = 119.$$

$$\therefore\ 100x + x^2 = 11900.$$

It is now advisable to arrange the terms, placing x^2 first, and then the term containing x on the left side of the equation, and the quantity not containing x on the right side of the equation; thus $x^2 + 100x = 11900$.

It will be found in most cases that the terms containing x^2 and x do not form a perfect square, and in many cases the other side does not either.

Before proceeding with the next step it is essential that the student should be thoroughly acquainted with certain algebraical identities; thus, whatever the quantity a may be

$$x^2 + 2ax + a^2 = (x + a)^2$$

and $$x^2 - 2ax + a^2 = (x - a)^2$$

Now, the expression, $x^2 + 2ax$, is not a perfect square, but if we add to it the term a^2, the trinomial expression becomes a perfect square; so that, in any case, when the terms in x^2 and x are given, the square may be completed by adding a term without x equal to the square of half the coefficient of x. The coefficient of x is $2a$, half of this coefficient is $\frac{2a}{2} = a$, and the square of half the coefficient of x is

$$\left\{\frac{2a}{2}\right\}^2 = a^2$$

Now take the expression $x^2 + 100\ x$. It is not a perfect square, but if we add to it the square of half the coefficient of x, the trinomial expression becomes a perfect square. The coefficient of x is 100, and

$$\left\{\frac{100}{2}\right\}^2 = 50^2 = 2500.$$

The truth of any equation is not altered if we add the same quantity to both sides of the equation, hence we can add 50^2 to the left side, and 2,500, the equivalent of 50^2, to the right side; therefore our equation now becomes (in perfect squares)

$$x^2 + 100\ x + 50^2 = 11900 + 2500.$$

$$\therefore\ (x + 50)^2 = 14400.$$

Taking the square root of each side

$$x + 50 = \pm 120$$

Either, $\therefore\ x + 50 = +120$

$\therefore\ x = 120 - 50 = 70$

or $x + 50 = -120$

$\therefore\ x = -120 - 50 = -170$

$\therefore\ x = 70$ or -170—*Answer.*

It will be seen that both these solutions are correct ones, for if $x = 70$, then $x^2 + 100\ x = 11900$

$\therefore\ 70^2 + 100.7 = (4900 + 7000) = 11900$;

and if $x = -170$, then since $x^2 + 100x = 11900$

$\therefore\ (-170)^2 + [100 \times (-170)] = 28900 - 17000 = 11900.$

The steps required then to solve an adfected quadratic equation may be taken as follows:—

(1) Simplify the equation so that the terms x^2 and x are on the left side of the equation and the term without x on the right side.

(2) If the coefficient of x^2 is not *unity* and *positive* make it so. This may be done by dividing throughout the whole equation by the coefficient of x^2.

(3) Add to each side of the equation the *square of half the coefficient of* x.

(4) Take the square root of each side and solve the simple equation resulting therefrom. It has been shown that there are two solutions, but the conditions laid down in the problem will very often show one of these solutions to be inadmissable. As showing this we will, for purposes of instruction, take the following example:—

> Q.—*A cistern can be filled by two pipes running together in* $22\frac{1}{2}$ *minutes; the larger pipe could fill the cistern in 24 minutes less than the smaller one: find the time taken by each.*

A.—Here it may be supposed that the two pipes if allowed to run singly would fill the cistern in x and $x - 24$ minutes, *i.e.*, the smaller pipe would occupy x minutes and the larger pipe $x - 24$ minutes. When running together they will fill $\left\{\frac{1}{x} + \frac{1}{x - 24}\right\}$ of the cistern in one minute. But they fill $\frac{1}{22\frac{1}{2}}$ or $\frac{2}{45}$ of the cistern in one minute.

Hence, $$\frac{1}{x} + \frac{1}{x - 24} = \frac{2}{45}$$

from which $2x\ (x - 24) = 45\ (2x - 24)$

$\therefore\ 2x^2 - 48x = 90x - 1080.$

$\therefore\ 2x^2 - 138x = -1080.$

Dividing by 2 $x^2 - 69x = -540.$

Add to each side the square of half the coefficient of x.

Then $x^2 - 69x + (34{\cdot}5)^2 = -540 + 1190{\cdot}25.$

$\therefore\ (x - 34{\cdot}5)^2 = 650{\cdot}25.$

$\therefore\ x - 34{\cdot}5 = \pm 25{\cdot}5.$

Either, $x - 34{\cdot}5 = +25{\cdot}5$

when $x = 25{\cdot}5 + 34{\cdot}5 = 60$ mins.

or $x - 34{\cdot}5 = -25{\cdot}5.$

when $x = -25{\cdot}5 + 34{\cdot}5 = 8$ mins.

It will easily be seen that the latter solution, $x = 8$ mins., is quite inadmissable and therefore $x = 60$ minutes. Thus the smaller pipe takes 60 minutes, and the larger pipe takes $60 - 24 = 36$ minutes.

For those students who like formulæ and can easily remember such, a formula may be found for the values of x which satisfies the quadratic equation when adfected. Every quadratic equation, after suitable reduction and transposition may be reduced to the form

$$ax^2 + bx + c = 0,$$

that is, every quadratic equation can be so simplified and arranged that it will possess one term with x^2, another term with x, and a third term without x in it. We may let a, b, c denote the various coefficients, and as such, these letters may have any numerical values whatever, but are supposed to be known quantities. It will be seen that a *pure* quadratic equation will be one in which the coefficient of x is 0; an *adfected* quadratic equation will be one in which the coefficient of x is

of some numerical value. For example: the equation $4x^2 = 64$ may be written thus, $4x^2 + 0x - 64 = 0$.
This is in the form of $ax^2 + bx + c = 0$,
when $a = 4$, $b = 0$, and $c = -64$.

We can now proceed to solve the equation—

$$ax^2 + bx + c = 0.$$

Transposing, $ax^2 + bx = -c$;

dividing each side by a, $x^2 + \frac{bx}{a} = -\frac{c}{a}$

To complete the square of each side, since neither side is a complete square, we must add the square of half the coefficient of x.

Half the coefficient of x is $\frac{b}{2a}$

Adding $\left\{\frac{b}{2a}\right\}^2$ to each side,

$$\therefore x^2 + \frac{bx}{a} + \left\{\frac{b}{2a}\right\}^2 = -\frac{c}{a} + \left\{\frac{b}{2a}\right\}^2;$$

$$\therefore x^2 + \frac{bx}{a} + \left\{\frac{b}{2a}\right\}^2 = -\frac{c}{a} + \frac{b^2}{4a^2};$$

$$\therefore \left\{x + \frac{b}{2a}\right\}^2 = \frac{b^2 - 4ac}{4a^2};$$

$$\therefore x + \frac{b}{2a} = \pm \frac{\sqrt{b^2 - 4ac}}{2a};$$

$$\therefore x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$

$$\text{or } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

This formula gives the two roots of the quadratic equation $ax^2 + bx + c = 0$ for any values of a, b, and c by taking first $+$ and then $-$ in the sign $\pm$; *i.e.*,

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$$\text{and } x = \frac{-b - \sqrt{b^2 - 4ac}}{2a}.$$

This solution is very important and the formula ought really to be learnt by heart for it is possible, by it, to solve any quadratic equation, although shorter methods may be used to solve many. Suppose it is required to solve the following problem:—

Q.—*The length of a rectangular area of coal exceeds its breadth by 30 feet, and its area is 5,400 square feet. Find its length and breadth.*

A.—Let x = number of feet in the length,
and $x - 30$ = number of feet in the breadth;
then since area = length × breadth
$\therefore$ Area = $x(x - 30)$ square feet.
$\therefore$ $x(x - 30) = 5{,}400$.
$\therefore$ $x^2 - 30x - 5{,}400 = 0$.
Here $a = 1$, $b = -30$, and $c = -5400$.

Hence
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$= \frac{-30 \pm \sqrt{900 + 21600}}{2}$$
$$= \frac{-30}{2} \pm \frac{\sqrt{22500}}{2}$$
$$= -15 \pm \frac{150}{2}$$
$$= -15 \pm 75.$$

Therefore the length is 90 feet and the breadth is $90 - 30 = 60$ feet, and area is equal to $90 \times 60 = 5400$ square feet.

Solving the same equation by factors:—

Since $x^2 - 30x - 5400 = 0$.
Or, factorising $(x - 90)(x + 60) = 0$.
$\therefore$ either $x - 90 = 0$, or $x + 60 = 0$.
$\therefore$ $x = 90$, or $x = -60$.

The positive solution gives 90 feet for the length, and 60 feet for the breadth, and area $= 90 \times 60 = 5{,}400$ square feet, which is correct.

The negative solution gives -60 feet for the length, and -90 feet for the breadth; and $-90 \times -60 = 5400$ square feet for the area. The negative solution would fit the problem when stated:—The breadth of a rectangular area is less than its length by 30 feet, and the area is 5,400 square feet. What are the dimensions?

Another example of similar character but of great importance is the following:—

Q.—*A rectangular pillar of coal is 10 yards longer than it is broad. If its length is increased by 20 yards and its breadth decreased by 10 yards its area is unaltered. Find its length and breadth.*

A.—Let x denote its length, then $x - 10$ denotes its breadth, and since length × breath = area, then $x(x - 10)$ = area.
When x is increased by 20 it becomes $x + 20$, and when $(x - 10)$ is decreased by 10 it becomes $x - 10 - 10 = x - 20$.
$\therefore$ Area $= x(x - 10) = (x + 20)(x - 20)$.
$\therefore$ $x^2 - 10x = x^2 - 400$.
$\therefore$ $-10x = -400$.
$\therefore$ $x = \frac{400}{10} = 40$ yards,
and the pillar is 40 yards long and $40 - 10 = 30$ yards broad.

Proof.—40 yards length × 30 yards breadth = 1200 square yards.

When length is increased by 20 yards it becomes $40 + 20 = 60$ yards, and when breadth is decreased by 10 yards it becomes $30 - 10 = 20$ yards, but its area is unaltered because $40 \times 30 = 60 \times 20 = 1200$ square yards.

Quite a number of important problems involving mining calculations and measurements can be solved by a knowledge of quadratic equations, either pure or adfected. The principle has here been carried through a number of useful examples to show its application, and students will do well to study the methods through and try to solve problems by their ageney.

VIEWS AND REVIEWS.

WIRING CALCULATIONS *for Electric Light and Power Installations.* By G. W. Lummis Paterson; Price 5s. net. London: Scott, Greenwood and Son, Ludgate, E.C.

This book is designed for the use of Architects, Engineers, Mining Engineers, Electricians, Wiremen, and others engaged in Electrical installation work. Its object is, as stated in the preface, to provide in a compact and easily accessible form the rules, formulæ, data, and other particulars required in connection with the calculation of electrical wiring for light and power. This object the Author has kept in mind, and has written the book in such a clear, compact manner as to at once appeal to the reader's attention. It is without unnecessary elaboration and all superfluous matter has been eliminated. The various sections treat on:—(1) Systems of Electrical Distribution; (2) Direct Current Wiring Calculations; (3) Direct Current Motor Wiring Calculations; (4) Data Relating to Direct Current Motors; (5) Data Relating to Direct Current Dynamos; (6) Alternating Current Wiring Calculations; (7) Alternating Current Motor Wiring Calculations; (8) Calculation of Alternating Current Exposed Wiring Circuits; (9) Data Relating to Alternating Current Motors; (10) Insulation Resistance. In the remaining sections, tables are given showing Minimum Insulation Resistance of Electric Light Installations from 1 Lamp to 150 Lamps. Particulars of Electrical Conductors — Conductivity — Weight — Tensile Strength, &c. Wiring Capacity of Metal Conduits. Carrying Capacity of Conductors at various Voltages and Efficiencies, &c.

Its 96 pages are brimful of valuable information with many worked-out examples and problems; whilst the 35 tables form a special feature of the work. It may safely be accepted as representing modern practice, and whilst recommending it to Electricians and Candidates for First-Class Colliery Manager's Examinations, we might add that it is sure to be highly appreciated. The formulæ and method of calculation are within easy reach of all who possess an elementary knowledge of Mathematics.

NOTES FROM WALES.

By BRYCHAN.

Haulage.

Figures 153 and *154* will convey to the reader an idea of the principle of application of endless rope for haulage. A single-cylindered engine is made to give, by means of double reduction gearing, a low speed to a bevel throat pulley, round which the rope makes two and a half coils. This is necessary in order to avoid slip, and to compel the rope to travel at the speed given to it by the pulley. The latter is called the driving pulley. The rope comes on to the pulley on the large diameter and goes off from the small diameter part, thence over one of a pair of sheaves (which may or may not be arranged in the same vertical or horizontal plane) down the shaft, round another pulley at the shaft bottom, and from there passes one and a half or two and a half times round a large pulley mounted upon a vertical axis. This becomes the driving pulley for the haulage of as many separate districts as there are pulleys and clutch gear fixed on the same shaft. In the figure there are two, and these for under rope haulage are fixed below the floor. Each is fitted with a friction clutch *FC* so that it may be stopped at any time without affecting the others. It is assumed that the engine, once started, works continuously throughout the shift, irrespective of any stoppages that may be necessary in the various districts; the shaft rope, sometimes called the

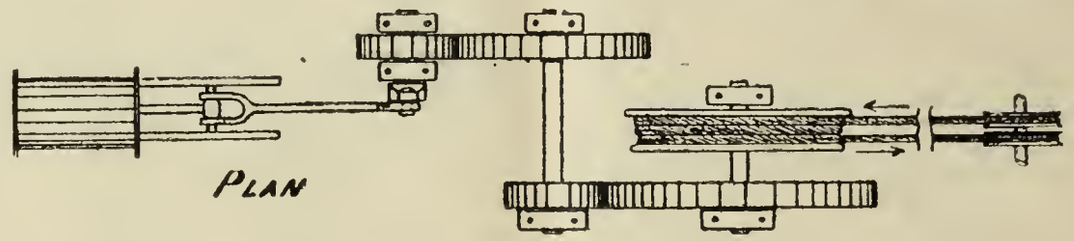
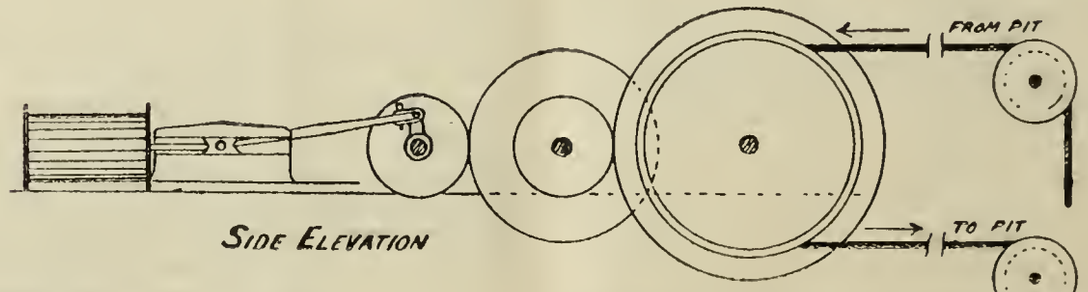


Fig. 153



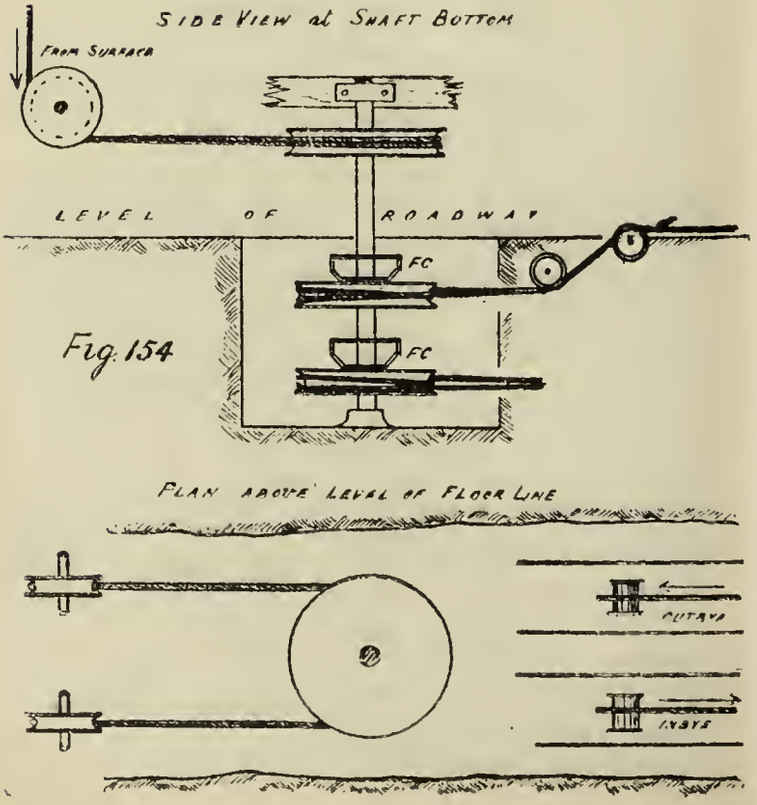


Fig. 154

band rope or main rope, is, therefore, always in motion. The speed is low, and there is no necessity for boxing up in the shaft. Tightening arrangements are very important in endless haulage, but are purposely omitted from the diagrams for the sake of clearness.

Wheel Gearing.—When we speak of gearing in machinery we mean that power is transmitted from one pulley or wheel which is called a "*driver*" on to another pulley or wheel, which is called the "*driven*" or follower. The wheels may be in contact, in which case they are termed toothed gearing; or they may be some distance apart, as in the case of belt or rope gearing. Now, suppose we call the larger of two such wheels the wheel, and the smaller the pinion. Then, when *pinions* are drivers the power is increased; when *wheels* are drivers the speed is increased. An instance of the latter will be the bicycle; of the former a winch or crab. In any geared hauling engine *pinions* are always drivers, because the object is invariably to secure an *increase* of power, and also a *reduction* of speed.

It must not, however, be forgotten that no amount of gearing can create energy. On the other hand, gearing *absorbs* energy. That is to say, the greater the amount of gearing introduced, the greater the power which must be taken from the engine to overcome the frictional resistances of same.

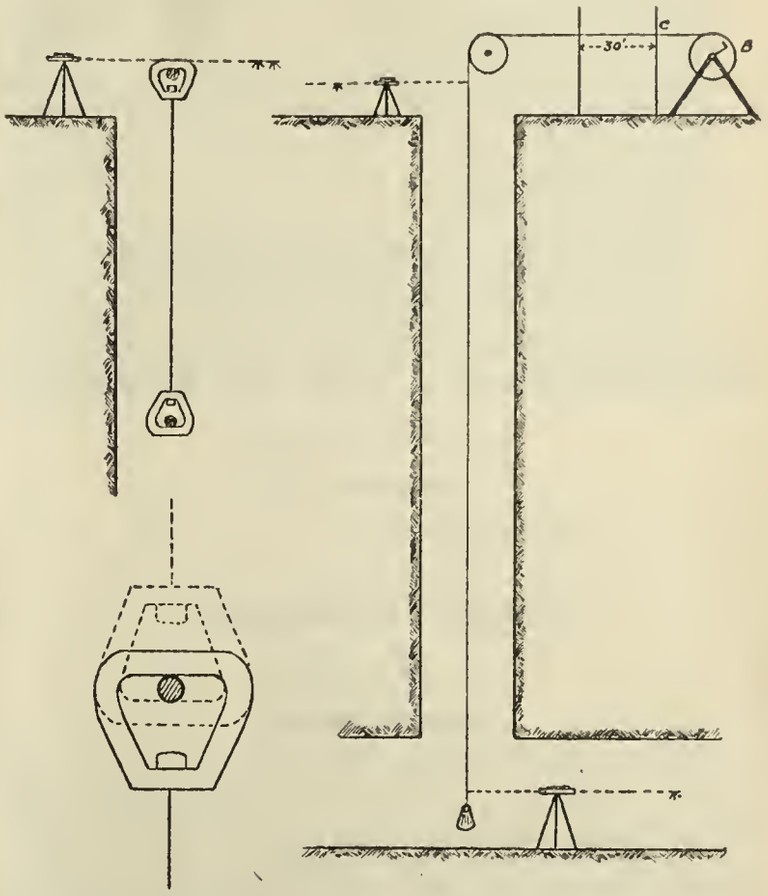
SURVEYING.

By COLLIERY SURVEYOR.

Measurement of Depth of Vertical and Inclined Shafts.—It is very important that depth below a given point on the surface should be accurately known. A rough method is to note the position of an arm of the winding engine drum at the commencement of a wind, count the number of revolutions of drum and multiply this number by the circumference of the drum in feet. Another plan would be to measure the length of winding rope between two points: on the surface in the plane of the banking level, and at the bottom at the junction of the rope and cap. This length, plus the distance to the cage floor, is the measure of the depth of the shaft. A more accurate method would be to measure, by means of a standard steel tape, length after length vertically along the shaft lining, selecting an unobstructed course for the purpose. The first length is measured from a point at the shaft top which is made to coincide exactly with a bench mark cut into a wall or other permanent point available for future reference. A nail is driven in at this level, and the tape is hung thereon. The surveyor and his assistant ride on the cage top, and signal the cage to be lowered one tape length. Another nail is driven in at the exact distance, the cage is drawn up, and meantime the tape is coiled up and its end unhooked from the upper nail. The cage is again lowered, the tape hung on to the second nail, and another length is measured, and so on, the utmost care being taken to mark the tape lengths correctly. The last measurement is taken to a convenient position, whose level can be denoted by a bench mark let into the walling at the shaft bottom. By this process of hanging the tape from each nail, and marking the bottom end in each case by a nail driven inside the handle, *Figure 112*, the student will observe that the recorded depth is in excess of the actual depth by twice the thickness of the handle + the thickness of the nail for each length measured. Suppose the handle to be $\frac{1}{4}''$ thick, and the nail also $\frac{1}{4}''$ thick. Then, $2 \times \frac{1}{4}'' + \frac{1}{4} = \frac{3}{4}''$ to be deducted for each measured length. No correction will be necessary for the top end of the first length, provided the position of the nail relative to the collimation level is as in the figure.

A method very often recommended is shown in *Figure 113*. Strong piano wire wound on to a reel or bobbin *B*, to which is attached a handle, is fixed in a suitable position not far from the shaft. A small weight is attached to the end of the wire, and let down the shaft. The weight is raised and lowered two or three times, and finally it is allowed to remain suspended in the shaft for an hour or two to complete the stretching (if any) of the wire. A Dumpy level cuts a point on the wire at the shaft bottom, which is marked by tightly tieing a piece of white thread around it. Exactly the same thing is done at the shaft top. If now the exact distance between these two points denoted by the white thread be measured, we have the exact vertical distance between the bench marks at top and bottom respectively. To measure this distance two rods are carefully set up a certain distance apart, say 30 to 50 feet, and as the wire is very carefully wound in on its bobbin the measuring is done, commencing when the top white thread has come alongside rod *C*. In view of the difficulty of measuring the bottom section right on to the thread adjoining the weight, another method might be adopted. The Dumpy level at the shaft top is left undisturbed, and measuring commences from rod *C*, length after length until the bottom white thread is exactly cut at the shaft top by the horizontal wire of the telescope. The distance thus obtained is in excess of the actual depth by the amount of the distance from *c* to the plane of the surface telescope. This is allowed for by omitting to record the last complete 30 feet length. A fractional length must of course be counted.

Inclined shafts frequently present considerable difficulties in measurement. The most favourable case would be where the alignment is good and the gradient regular. By means of an instrument recording angles in a vertical plane the ∠ of depression can be determined, and the exact distance taken from the instrument to the light below. This distance, multiplied by the sine of the ∠ of depression or dip, will give the vertical depth to that point. In such a case the section of the shaft can be easily plotted as well. In the case of crooked shafts with irregular pitch the task of measuring their vertical depth is one of considerable difficulty, and resolves itself into a series



of straight edge and plumb line observations, the length of plumb line for each step being very carefully determined. The sum of all these will be the vertical depth of the shaft. Provided the horizontal length of each step is known there will now be sufficient data to plot correctly a transverse section of the shaft.

Examples to be Worked Out.

Readers working out the appended questions and who desire a test of their ability, should submit their answers to COLLIERY SURVEYOR, care of *The Science and Art of Mining* Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means answers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonies and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to COLLIERY SURVEYOR at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the regular series of articles.

1.—*How would you accurately measure the depth of a vertical shaft?*—City and Guilds, Grade II., 1912.

2.—*State the method you would employ to accurately determine the vertical depth, and also to plot the transverse section of an inclined shaft.*

3.—*A level is approaching a boundary, and its position is required to be accurately known. A surface survey draft* DE *coinciding with the boundary runs for 600 feet at an azimuth of 214° 11'.* D's *Northing = 925·2 feet, its Westing = 857·8 feet. Underground point 318 has its Northing = 823·4 feet, and its Westing = 942·8 feet. The draft in the level from 318 to 319 runs at an azimuth of 331° 20' for 48·2 feet. Determine the distance of station 319 from the boundary.*—City and Guilds, Grade II., 1912.

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The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, MAY 25, 1912.

COLLIERY ENGINEERING.

By CLANSMAN.

Graphical Methods.

Ability to make a neat dimensioned sketch and to make a drawing to scale of a machine part or any structure is an essential accomplishment of the engineer. He must not be content to view things which belong to his sphere from the standpoint of an ordinary admirer. The engineer must have an eye to details. Not only must he have in his mind an impression of the general effect and appearance of a mechanical device, but he must carefully note and understand every single part which goes to form the whole. With a few lines sketched in his note-book having dimensions carefully noted he can in many cases carry away a more minutely detailed description of a machine than if he had filled pages in an elaborate word picture. Nor does the advantage end here. By graphical methods it is possible to make a more exact representation of some quantities than can be done by means of arithmetic, and certain quantities can be found much more easily by graphic than the ordinary arithmetic. The practical man is continually making calculations, and there is always the risk of errors finding their way into his work. The graphic methods provide a reliable and independent alternative by which the calculations can be checked. For this work we must provide ourselves with drawing instruments, a pair of set squares (45° and 60°), a protractor, and a good set of scales.

The Use of Scales.—In making a drawing of any large object or any large quantity it would be inconvenient and in many cases impossible to draw it full size, that is, as large as the object itself. But it is possible to get the exact proportions by drawing it half size, quarter size, or to some convenient scale. Every line on the object is set down in its proper place in the drawing, but only a certain fractional part of the total lengths of these lines is drawn. In every line the same fractional part is taken, and so the scale is said to be $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{24}$ full size or whatever fraction may have been decided upon as the most convenient. Thus, we may make every one inch of line drawn represent an actual length of 12 inches, and the scale would be $\frac{1}{12}$; or one-eighth inch on the drawing to represent an actual length of one foot, and the scale would be $\frac{1}{96}$, and so on.

Hence, the representative fraction of a scale

$$= \frac{\text{Number of units in any line on the drawing}}{\text{Number of units the line represents}}$$

For this reason we find all scaled drawings have the representative fraction of the scale employed, marked clearly on the drawing. Thus: Scale $\frac{1}{2}$ full size; scale $\frac{1}{4}$ full size; or scale 6 inches = 1 foot; scale 3 inches = 1 foot, and so on.

To Construct a Scale.—Scales to suit all the engineer's requirements can be bought, but it may sometimes be necessary for him to construct his own scales. For example, he may be given a plan on which no scale is indicated, but the lengths of the lines marked in plain figures. In that case it is easy to construct the scale.

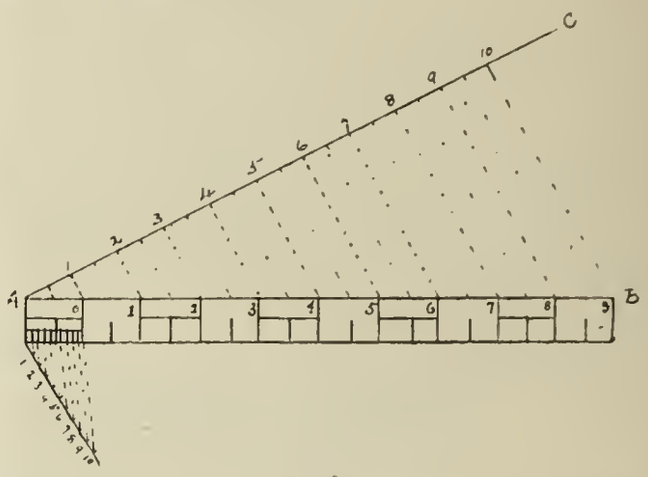


Figure 7.

Let *AB* (*Figure 7*) be a line representing 10 feet on any plan, to construct a scale on it.

Draw a line *AC* at any convenient angle, and mark off any 10 equal lengths on it. This is done simply by taking any short length on the compasses, and stepping this distance ten times along the line. Join the tenth mark to *B*, and with the set squares draw lines parallel to 10 *B* through the successive points 1, 2, 3, 4, 5, 6, 7, 8 and 9. The line *AB* is now divided into 10 equal parts, and each part represents one foot. To

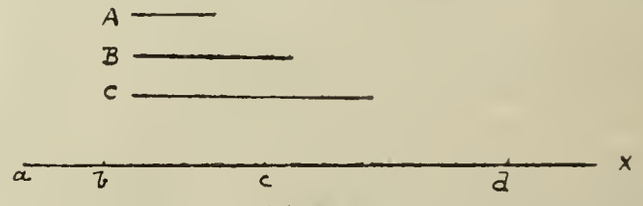


Figure 8.

make the scale draw a line parallel to *AB*, and draw perpendiculars through the divisions 0 to 10. If we require smaller divisions than the foot the first division 0 to 1 may be divided into any equal number of parts. In sketch we have divided it into 10 parts, and, therefore, each part represents one-tenth of a foot to scale of plan.

Graphic Arithmetic.

Numbers may be represented by lines drawn to a suitable scale and ordinary arithmetical results obtained by geometrical construction.

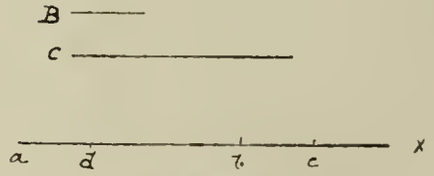


Figure 9.

By a suitable scale we mean a scale small enough to allow of the lines being drawn on the sheet of paper we are working with. Generally speaking, the larger the scale we use the more accurate will the result be. A sharp chisel-pointed pencil should be used, and the lines drawn thin. If care is exercised the error, even with a small scale, will not be great.

Addition.—To find the sum of any number of lines place them end to end, and in the same straight line; then the total length so obtained is the sum required.

Let *A*, *B* and *C* (*Figure 8*) be any three lines, to find the sum of them. Draw a straight line *ax*, and along it make *ab* = *A*; *bc* = *B*; *cd* = *C*. Then *ad* = *A* + *B* + *C*.

We simply take the length *A* in the compasses, and with *a* as centre mark off *ab* = *A*, and so on, taking always the last point marked as the centre for the next length, and proceed always in the same direction along the line.

Subtraction.—To find the difference between one set of lengths and another, place them end on and in the same straight line, but those added are marked off in one direction, while those subtracted are marked off in the other.

Let *A*, *B* and *C* (*Figure 9*) be any three lines to find the difference of *A* + *B* and *C*. That is, we are asked to add *A* and *B* together, and subtract *C*.

Draw an indefinite straight line *ax* and make *ab* = *A*, and *bc* = *B*, measuring always to the right for + quantities. Then take a length equal to the line *C* in the compasses, and with *c* as centre mark off *cd* in the opposite direction, *i.e.*, to the left. Then *ad* = *A* + *B* — *C*.

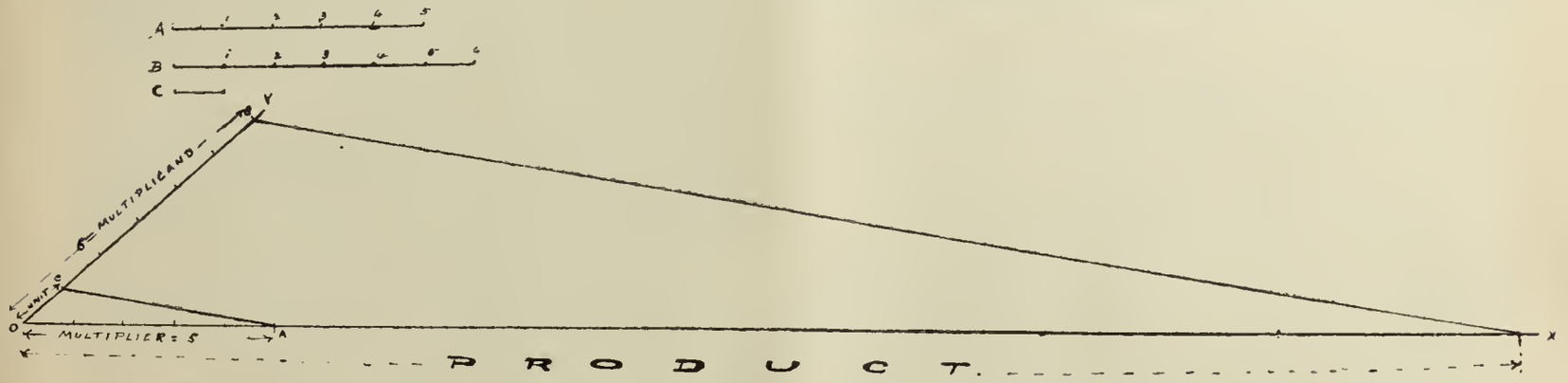


Figure 10.

In this case the answer *ad* is positive, but if *d* had been to the left of *a* then *ad* would have been negative.

Multiplication.—To find the product of two lines draw two indefinite lines inclined to each other at any convenient angle (90° is perhaps simplest). On one of these lines set off from the intersecting point, one of the lines to be multiplied; on the other line set off the remaining factor. On either line set off a distance equal to the unit employed, and join this to the end of the factor drawn on the other line. If now a line be drawn parallel to this through the end of the other factor it will cut off a length on the other line equal to the product required.

Let *A* be a line 5 units long;
B be a line 6 units long;
and let *C* be a line representing the unit employed. See *Figure 10*.

Draw lines *OX* and *OY* at any convenient angle.
On *OY* make *OB* = *B*, and on *OX* make *OA* = *A*.
On *OY* make *OC* = *C* the unit, and join *CA*.
Now draw a line parallel to *CA* through *B*, cutting *OX* at *L*.
Then *OL* = *A* × *B* = 5 × 6 = 30 units.

JAMAGE PIT EXPLOSION.

In his report on the explosion which occurred in the Jamage Pit of the Bignall Hill Colliery on November 25th, 1911, whereby six lives were lost, Chief Mines Inspector R. A. S. Redmayne presents the following conclusions:—

The Cause of the Explosion.—I am of opinion that the explosion was purely a gas explosion—that is to say, coal dust did not participate in it at all—and was caused by a mixture of fire-damp and air which became ignited by a fire in the gob.

Had it not, however, been for the fact that the stoppings shutting off the fire broke the force of the explosion—that is to say, had there been a free vent—in all probability the coal dust in the roads would have carried the explosion out to the shaft, as was in all probability the case with the subsequent explosion.

I think the explanation advanced by Mr. Henshaw, and concurred in by Mr. Mitcheson, to account for the existence of the gob-fire, is probably the correct one, namely, that the gob being an open one, and the strip of coal, in which Nos. 7 and 8 stoppings were built, being much fractured owing to its thinness and the "weighting," and the stoppings, especially No. 7, being the reverse of air-tight, air would leak through both coal and stopping, causing a certain amount of "aspensional ventilation" to pass through the goaf, sufficient to set up oxidation in the fallen coal and "hussle" in the goaf, but insufficient to carry away the heat due to the same. Mr. Mitcheson said "the unfortunate part about it, to my mind, is that not only did this small current of air cause the heating, but it prevented evidence of what was taking place in the goaf being disclosed at the open edge of the goaf where the men were working." I agree with him, and think that this fire had been smouldering for some time, and that the stopping off of the affected area—shutting off as it would all ventilation from the goaf—allowed the fire-damp to accumulate and so produce the explosive mixture. I am unable to point to the *exact* spot in the goaf at which the fire originated.

The Erection of the Stoppings.—The distance from the goaf at which the stoppings were erected is considerable, and from an inspection of other parts of the mine where somewhat similar conditions existed in respect of proximity of goaf and its effect on the coal pillars and the height of the roads, I am not satisfied that the stoppings could not have been erected nearer to the goaf. Whether, however, there would have been any advantage in doing this is a question which is open to doubt. It is conceivable that it might have been the means of bringing about the conditions necessary to cause the explosion sooner than was actually the case. On the other hand, it would probably have limited its force, or possibly have prevented its occurrence. The matter is problematical, depending as it does on a variety of uncertain factors.

I lean to the view, concurred in by Mr. Rigby, that "there was sufficient air built up in the place to cause the explosion." He safeguarded his statement, however, by adding that it "could not be avoided under the circumstances" owing to the distance from the goaf the stoppings had to be put in.

On one point, however, I am quite clear—and here I am in disagreement with Mr. Henshaw—that far too much time was expended in building off the affected area. The work of damming off a fire in a gassy pit is always an operation attended with great danger, as case after case has shown. The risk of the occurrence of an explosion is great, hence the quicker the sealing off is effected and the men engaged in the work are withdrawn from the pit the better. It would have been wise to have reversed the order of procedure adopted by Mr. Daniels and to have first built the brick dam, to have then withdrawn the men, and, say next day, if nothing had occurred, to have proceeded with the strengthening of the same with outside dirt packs. Or, as Mr. Johnstone very clearly stated the question, "if there is to be time to build dirt packs for 27 hours" (the time actually spent in building the dirt packs) "there would

have been time to build bricks "for three hours *plus* dirt packs for 24 hours—in which case the brick *plus* the dirt would have been quite as strong as the dirt without the brick, and the effect of putting in the brick first would have been that the air would have been sealed off, wholly or partly, many hours before it was done."

Practice in respect of the Prevention of Gob-Fires at the Colliery.—I directed a large part of my examination of witnesses to the subject of the ventilation of the goaf.

It was the practice at the colliery to prevent air as far as possible from circulating in the goaves (which are of an "open" character, that is to say, the roof being composed of a strong shale and the seam being a thick one, on the extraction of the coal a cavernous space is left, and a long time elapses before this becomes closed), the idea being that, when the seam is highly inclined, the gas rising to the higher part of the waste renders the atmosphere of the goaf incapable of supporting combustion owing to insufficiency of oxygen, and it was reasoned that this constituted a preventive to gob-fires occurring in the goaf, such a condition of atmosphere, always provided the goaf remained unventilated, following the retreating workings downhill.

When working to the rise it was possible to pack the goaves with water and in that manner prevent the occurrence of gob-fires.

But when working the pillars when the seam was flat or moderately inclined, neither of these preventive measures was available, but the former appears to have still been followed.

If heating occurred in the coal at any point which was accessible, the management filled away the coal. The manager informed me that they had only one case of spontaneous combustion in the goaf within the last twelve months.

Mr. F. Rigby's evidence in respect of the means taken to prevent gob-fires in North Staffordshire is of great value, as he has had forty-two years' experience in the management or ownership of mines in that district, and during practically the whole of this time he has been engaged in working the Bullhurst seam.

Prior to 1886 he adopted the system of ventilating the goaf. At that time the whole question of gob-fires "had become a very serious one along the whole side of the district, and we—myself, my managers, and other engineers—had many discussions as to adopting some other method." Finally they came to the conclusion that the best method would be:—

1.—To have as few roads as possible into a given district.

2.—So to control the ventilation that as little air as possible should traverse the goaf, or, as he expressed it, "to keep control of the ventilation and confine it to where it was really required, along the working places, but preventing absolutely, if possible, a circulation of air through the goaf."

He has carried out these principles for the last twenty-five years with success, working long wall wherever possible, and "keeping control of the ventilation by means of the most perfect pack we could put in," *i.e.*, so arranging the packs in the long wall that the goaves were as tight as possible, and the air is confined to the face. Preparatory stoppings were put into the main roads, so that if any trouble arose in respect of gob-fires these were "in preparation for closing as quickly as possible."

The mode of procedure sketched by Mr. Rigby, and successfully adopted by him, requires for its successful working a mine systematically laid out. All the experts were agreed that the Jamage mine could not be so characterised.

But, as I have previously stated, for the want of method in laying out the Jamage mine the present manager is in no wise to blame. The mine was laid out long before he took charge, and I observe that, in respect of new developments, he was proceeding on better lines than had been followed in the past.

The owners produced a considerable amount of expert evidence to show that it was difficult to lay out the mine systematically owing to:—

(*i*) The great variety in respect of inclination of the seam;
(*ii*) The great variety in respect of thickness of the seam;
(*iii*) The extent of the faulting or dislocation in the continuity of the seam;

but they did not make out a case. By the advancement of exploratory roads, the presence and extent of these factors could have been determined, and a scheme of districts devised to meet the conditions so found. Thus, districts could have been so arranged as always to have been worked to the rise or to the dip whichever was considered best. I have myself worked, and seen worked, seams the workings of which were divided systematically into districts, in which the faulting was far in excess of that at Jamage.

The variation in respect of the thickness of the seam determines only the mode of working the coal, *e.g.*, whether by the "bord and pillar" or by the "long wall" method, or modifications of these.

The Hydraulic Stowage of Goaves.—There is no doubt that for the purpose of combatting gob-fires, the long wall mode of working coal is the best method to pursue if it is possible to pack the wastes tightly. It was argued that at the Jamage mine the Bullhurst was too thick, and that there was not a sufficiency of packing material to allow of the goaf being properly stowed, and I agree in respect of the latter contention. But I am of opinion if this seam had been worked by the long wall method—and I think it could have been worked by a modification of that method—the hydraulic system of packing the goaf could have been adopted with success. This system is practised at many collieries on the Continent, and could, I believe, be successfully adopted at many collieries in the United Kingdom where it would render the occurrence of fires in the gob impossible. It consists briefly in forcing crushed material derived from the spoil heaps on the surface mixed with water through pipes laid down the shaft and into the workings, the forcing power being the head due to depth of shaft, and in some cases, the additional head created by the dip of the seam.

This method, as practised in the Lens in the Pas-de-Calais Coalfield, is described in pages 159-161 of the Report of a Committee appointed by the Royal Commission on Mines. The Committee there state that the system is "the most perfect of all means of stowage, inasmuch as it allows of a closer packing of the goaf than by any other method."

The other advantages of this method of stowage have been shown to be:—

(*i*) A saving in timber.

(*ii*) The possibility of keeping a longer length of face, hence less cost of upkeep of roads.

(*iii*) The procuring of a larger percentage of large (round) coal.

(*iv*) Reduced subsidence of surface.

The cost of stowing the goaf by this method at Lens Colliery in the Pas-de-Calais was shown to be ·85 franc (8·16 pence) per ton of coal raised exclusive of interest on capital, but the advantages accruing from the adoption of the method were estimated as equivalent to ·65 franc (6·24 pence) per ton.

For every 328 feet (100 metres) depth of shaft it is found possible to force the material along a horizontal distance of 1,968 feet (600 metres).

BOARD FOR MINING EXAMINATIONS.

In pursuance of the provisions of Section 8 (1) of the Coal Mines Act, 1911, the Home Secretary has appointed the following persons to be members of the Board for Mining Examinations:—Mr. Frank Brain, Mr. John Gemmell, Mr. Samuel Hare, Mr. A. H. Leech, Mr. G. Alfred Lewis, Mr. Evan Williams as representatives of owners or agents or mines, or managers of mines or mining engineers; The Right Hon. Charles Fenwick, M.P., Mr. Enoch Edwards, M.P., Mr. J. G. Hancock, M.P., Mr. Thomas Richards, M.P., Mr. Stephen Walsh, M.P., Mr. Robert Smillie, as representatives of workmen employed in mines. Mr. R. A. S. Redmayne, H.M. Chief Inspector of Mines; Dr. W. N. Atkinson, I.S.O., H.M. Divisional Inspector of Mines for the South Wales District; Mr. W. Walker, H.M. Divisional Inspector of Mines for Scotland; Dr. J. S. Haldane, F.R.S.; and Professor S. Herbert Cox, as persons eminent in mining and scientific knowledge.

The appetite for something cheap is never in need of a file to sharpen its teeth.

It is not often that one man harms another without breaking the finger nails that did the scratching.

A troubled conscience, like a blister, sometimes brings vitalised blood into dead skin.

PRIZE COMPETITION.

"Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, June 4th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 22, Vol. XXII., but in No. 23, Vol. XXII.]

PREPARATORY.

Q. 1. SIPHONS.—*Describe the principle and action of the siphon.*

Q. 2. VENTILATION.—*Which do you consider should be the larger, the main intake or return air-way, and why?*

Q. 3. SHOT-FIRING.—*Briefly describe two methods of firing shots. Which do you prefer, and why?*

Q. 4. SAFETY-LAMPS.—*Describe the construction of a safety-lamp of which you approve. Give your reasons for approving of it.*

SECOND CLASS.

Q. 5. VENTILATION.—*What circumstances would guide you in determining the quantity of air necessary for the ventilation of a mine?*

Q. 6. HAULAGE ROADS.—*Assuming that a large number of accidents occur on underground haulage roads. What precautions and rules do you consider necessary to insure the safety of persons working and travelling on these roads?*

Q. 7. SHAFT PILLARS.—*In determining the size of a shaft pillar what effect will the depth of the shaft and the inclination of the seam have?*

Q. 8. ROPES.—*What are winding and haulage ropes made of, and what regulations for their preservation are necessary in the interests of safety and economy?*

FIRST CLASS.

Q. 9. SQUEEZE.—*In case a squeeze occurs in a mine of which you have charge, endangering a heading and threatening to shut off part of the work, how would you proceed to stop its progress?*

Q. 10. SAFETY VALVES.—*What is the object of a safety valve on a steam boiler? What form of safety valve would you use?*

Q. 11. VENTILATION.—*What provisions would you make at a colliery for keeping up the ventilation in case of a breakdown of the ventilating appliances? In the event of a serious stoppage of ventilation when the men were at work, what action would you take?*

Q. 12. WINDING ENGINES.—*Is it necessary in colliery winding engines on the second motion to have a brake applied both to the crank shaft and also to the drum itself? Give reasons for your answer.*

Best Answers Received to Questions in No. 19, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Rope Boring.

Q. 1.—*Describe simply the method of putting down a deep bore-hole by the American system of rope boring.*

A.—The apparatus necessary for the boring of a hole to a great depth by the rope method is shown in the illustrations. The dimensions of the different parts may be set out as follows:—

Drilling Bit or Chisel.—Shown at *c*. It is 8 inches in width.

Auger Stem.—Shown at *d*. It is 3½ inches in diameter, 30 feet in length, and weighs about 1,000lb.

Jars.—Shown at *e*. These consist of two pieces of flat iron 5½ inches in width, and about 7 feet in length. One telescopes within the other. The slots allow a play of about 9 inches.

Sinker Bar.—Shown at *f*. In diameter about 3½ inches, and about 18 feet in length.

The above are termed the boring tools, and are connected as set out, viz., chisel to auger stem, auger stem to jars, jars to sinker bar, by means of screw joints. The rope socket is attached to the latter. The total weight of the set is about 2,000lb. and the length 62 feet. Their respective requirements are as follows:—

Chisel.—Cuts the ground, which is brought about by a quick percussive action.

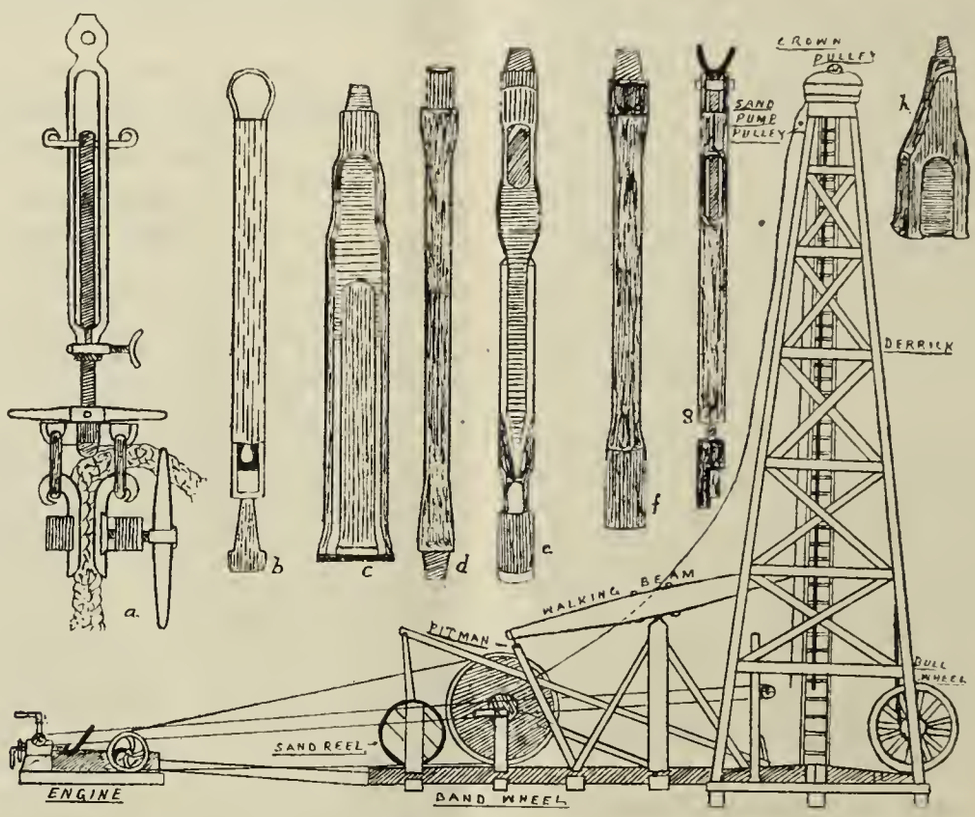
Jars.—To regulate the stroke. The force of the downward blow is entirely due to the free fall of the heavy chisel, auger stem and lower part of the jars. Main object of the jars not to give a blow on the downstroke, but to loosen the chisel by an upward blow during the upstroke.

The rope, which takes the place of boring rods, when compared with other methods of boring, is made of untarred manilla, and is 6 inches in circumference. Such rope, as stated, is connected to the sinker bar, and at the other end when boring is in progress is held by an appliance termed a temper-screw, the latter being connected to the walking-beam. (See figure). The temper-screw (*a*) allows the rope to be let out to the extent of about 4 feet as the boring progresses. When the screw is run out the tools are withdrawn. By means of the temper-screw a turning motion is given to the rods or rather tools at each blow; thus the chisel does not strike the same place successively. By reference to the figure (*a*) its action will be understood.

The walking-beam receives its rocking motion through the "pitman," an arm which is attached by a crank and axle

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

to a wooden wheel, 7 feet in diameter. The latter is known as the Band-wheel, and is driven by an endless belt off the engine. In length the walking-beam is about 26 feet. The driving engine is from 12 to 15 horse-power, and is of the locomotive semi-portable type. At the other side of the bore-hole the bull-wheel is placed. Thereon is coiled the boring rope. Its main parts are a roll, 10 feet in length and 13 inches in diameter, at each end of which are wheels 7 feet in diameter. A strong brake is provided, and the wheel is driven by a 2-inch rope off the "band-wheel" shaft. When the wheel is required to be put out of gear this rope is thrown off. The walking-beam is put out of gear by disconnecting the "pitman" from the "band-wheel," the connection being made by a "wrist-pin" and key. For clearing the hole of *debris* the "boiler" (*b*) and the sand-pump (*g*) are used. The sand-pump is a wrought-iron cylinder with a valve in its bottom end, and a plunger, the rod of which is attached to the rope. When the cylinder is lowered the weight of the plunger causes it to sink to the bottom of the same. When raised the plunger is first drawn up the cylinder, thus sucking in the *debris*. Water is generally needed for the use of the sand-pump, which is provided with



Illustrating Question 1.

a separate rope and reel, the reel being driven off the "band-wheel" by a friction pulley. This is moved by a lever inside the derrick so as to be under the control of the man at the bore-hole. The engine can also be started and stopped at such point by means of an endless cord passing around a small pulley on the throttle valve of the steam pipe, and a similar pulley in the derrick. The derrick consists of four wooden legs held together by ties and braces. It stands 70 feet in height, and is 20 feet square at the base. On the top is fixed the crown pulley around which the main boring rope passes. Another pulley is fixed near the top for guiding the sand-pump rope. When drilling through soft beds of sand and gravel which are generally found near the surface a special tool called the spudding-bit is used (*h*). It is connected to the auger-stem which is attached to the rope socket by a piece of cable about 160 feet in length. The cable is passed over the crown pulley at the top of the derrick and down to the bull-wheel. It is coiled around the same for a few turns to leave a loose end, which is held by the man in attendance. When operating the engine is started, and as the bull-wheel revolves the man at the rope end gives it a pull. This tightens the same in the rotating shaft, and thus raises the tools. Immediately the rope is slackened, allowing the tools to drop, and so the drilling proceeds. When passing through these soft beds it is necessary to line the hole so as to prevent the sides running in. Wrought-iron tubes are used for the purpose, being of 20-foot lengths. The tubes are driven down by means of a heavy wooden mall, 20 feet long by 14 inches square. It is raised and lowered with the aid of the bull-wheel in the same way as the spudding-bit. When one tube has been driven down to the surface level another one is connected by means of a screw joint, and the operation repeated. With the above apparatus two men per shift can do all the labour required, the vibration of the rope showing whether the work is proceeding all right or the opposite.

In conclusion the above method is one of the most rapid. It is an American system, and as an instance of what has been done by means of it, the following will not be out of place:—

Messrs. C. Tennant and Partners, in the year 1887, put down a hole 8 inches in diameter to a depth of 1,008 feet in twenty-two days near Port Clarence. As much as 95 feet were bored in one day, the average boring being 45 feet daily. The method was first introduced into England about the year 1886 for boring to the bed of rock-salt which is extensively worked in the Middlesborough neighbourhood. Such bed is found at a depth of about 1,000 feet, the intervening strata consisting chiefly of sandstones and marls.

For answer and sketches I am indebted to Boulton's *Practical Coal Mining*, Volume 1, pages 106–107.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

W. Heaton, J. Taylor, T. U. Parr, J. H. Spence, A. Davies, S. F. Middup, J. C. Rodman, T. Gaskell, E. R. Hindle, W. Williams, L. J. Thomas, J. Taylor, J. A. Hill, T. Yates (*12 marks each*).

Explosives.

Q. 2.—*Briefly and concisely, under what circumstances do you consider a high explosive preferable to ordinary gunpowder?*

A.—The Explosives in Coal Mines Order has certainly restricted the use of ordinary gunpowder in mines. Where inflammable gas has been seen it would be necessary, to comply with this Order, to use one of the high explosives in the permitted list. These are sometimes called "flameless explosives," but there generally is a slight flame.

The circumstances under which it is preferable to substitute one of the high explosives for gunpowder are: In mines where it is thought to be necessary to use safety-lamps, even though there has not been any dangerous quantity of gas found in the mine. It would be always best to use gunpowder for blasting in coal if possible, therefore I would never use a high explosive which does not have the same shattering effect on the coal. The chief objections to the high explosives are their action is quicker than gunpowder, and has a more shattering effect on the coal; they are more troublesome to fire; special men are required for firing; and the cost is greater.

When, in taking down roof, blasting has to be resorted to, I would consider a high explosive preferable to gunpowder. The hard roof which would make blasting necessary would be much more easily broken up after a shot fired with a high explosive than would be the case if gunpowder were used.

If the mine was not of a damp nature I would much prefer to use a safety explosive, as with gunpowder there is a considerable flame. This flame may easily ignite any dry coal dust which may be in the vicinity of the shot, this liability being greater than with the smaller flame of the high explosive.

Speaking generally, in almost all circumstances I would prefer a high explosive to ordinary gunpowder. The dangers attending shot-firing are generally blown-out shots and flame. With a high explosive these dangers may be distinctly lessened, and this in itself greatly counterbalances the shattering effect of high explosives. Safety is a great consideration when choosing explosives.

Wm. Williams, 28, Curre Street, Cwm, Monmouthshire.

[NOTE.—We do not know that any high explosive is superior to gunpowder looked at merely from the point of view of getting down the coal with a minimum of injury to it, though certainly there are some explosives whose action on coal is little inferior to that of gunpowder. We have now indirectly answered the question. We consider that the use of a high explosive is to be preferred to that of gunpowder in every case except where it is required to bring down the coal in a mine which is neither dry nor dusty, and in which naked lights are used.—C.C.M.]

J. Taylor, W. Heaton, S. Beardsley, C. Simpson, A. Davies, J. C. Rodman, J. A. Hill, T. Gaskell, E. R. Hindle, F. Mitchard, L. J. Thomas (*12 marks each*).

F. Kershaw (*8 marks*).

Superheated Steam.

Q. 3.—*What advantages are claimed for superheated steam?*

A.—Before giving the advantages to be derived from superheated steam, it will perhaps not be out of place to explain what is meant by superheated steam, as it will help us to understand the advantages claimed for it. Ordinary steam may be said to be the vapour of water produced by the application of heat to it. If water at a certain temperature, say 32° Fahr., is heated until a temperature of 212° Fahr. is attained throughout, the water commences to boil. If we continue to supply heat to it, as is the case when producing steam in boilers, we get what is called saturated steam. This is steam which is in contact with the water in the boiler.

Superheated steam is steam which has been freed from contact with the water in the steam boilers, and has had additional heat imparted to it afterwards by some special superheater, designed and fixed usually at the back end of steam boilers for the express purpose of supplying the additional heat, to produce what is known as superheated steam.

It will be evident that superheated steam will claim advantages over and above ordinary saturated steam. Whereas saturated steam will be of somewhat great density, superheated steam will be a nearer approach to a true gas, a great advantage, as there will be practically no condensation in the pipes leading to the engines.

Superheated steam claims special advantages, as it enables us to employ compound and expansion engines to the best advantage. Superheated steam used for compound engines produces a much higher degree of economy. As we know, the steam is first admitted into the high pressure cylinder, and after doing its work it is exhausted into the low pressure cylinder, where it again does useful work. Thus we see that a higher degree of expansion is obtained, due to the fact that superheated steam is more like a perfect gas, enabling us to work the engines better on the expansive principle with better results.

Superheated steam claims great advantages, because the power of steam depends upon the amount of heat it possesses, superheated steam being great in this respect.

Superheated steam prevents condensation to any great extent. There is also less leakage during transmission and past valves, pistons, &c., of the engines when being used. It also flows easily through pipes, being like a perfect gas, which is a great advantage, as it causes less drop in pressure between the steam chest and the cylinder of the engine during admission, and reduces the back pressure when exhausting.

In conclusion, superheated steam claims advantages economically, as there is a great saving in the consumption of steam and fuel, because it is possible to get the maximum amount of work out of the steam before condensation takes place.

Thos. Gaskell, 138, Downall Green Road, Bryn.

[NOTE.—Saturated steam is always liable to condensation on meeting any surface cooler than itself. A large amount of condensation takes place when carrying saturated seam along fairly long lengths of pipes from the boilers to the engines. Besides reducing the pressure, this tends to the collecting of water in the cylinders, which, of course, is not by any means to be desired. With superheated steam, besides gaining largely as regards economy, we are able to adequately guard against this condensation.—C.C.M.]

W. Williams, L. J. Thomas, E. R. Hindle, T. G. Lippitt, F. Mitchard, J. C. Rodman, J. H. Spence, T. U. Parr, C. Simpson, J. Taylor (*12 marks each*).

J. L. Burton, F. Kershaw, G. H. Fearn (*8 marks each*).

Walling Cribs.

Q. 4.—*If you were engaged in fixing a walling crib or curb in bad ground, what precautions would you take?*

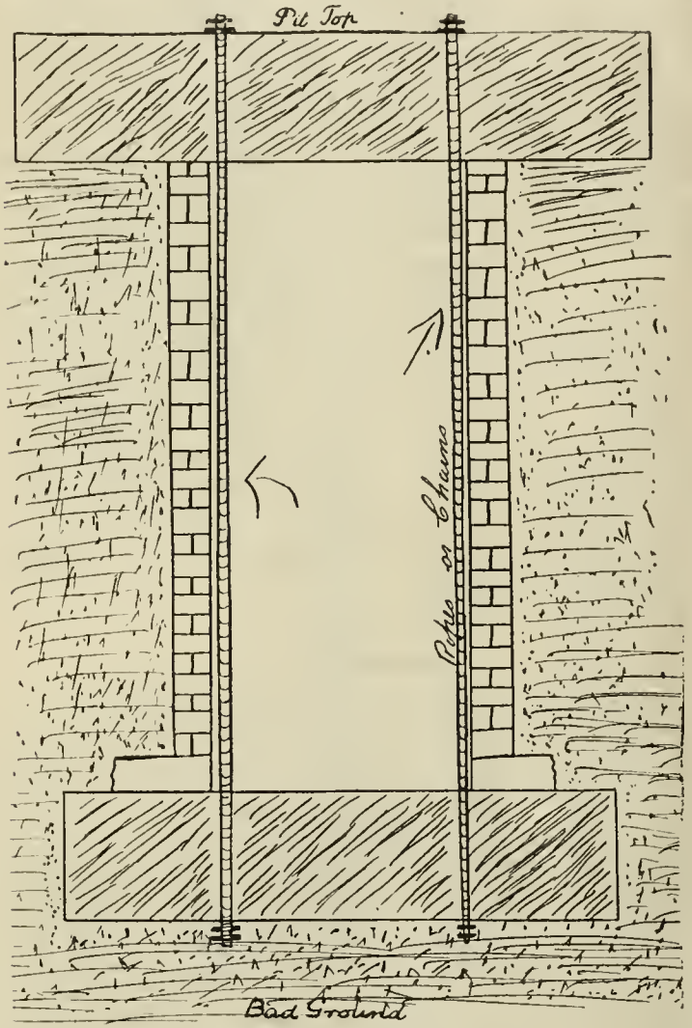
A.—The fixing of a walling curb in bad ground requires special attention, and demands every precaution. We know that a walling curb under any circumstances in a sinking pit requires to be fixed permanently, and supported without fear of its giving way when the sinking operations are being proceeded with below it. Under such circumstances some special method will have to be adopted out of the ordinary to fix and support the curb to the best possible advantage from a safety point.

Seeing that the curb has to be fixed in bad ground, it is quite possible that this may happen when the first walling curb is required from the surface. The method of fixing and supporting a walling curb, in my opinion, would be to have four wooden balks stretched across the mouth of the shaft, forming a square. I would examine these balks minutely, previous to fixing them in position, satisfying myself that the material was sound and fit for the purpose of supporting the curb. Having fixed these balks in position on the surface, the next operation would be to fix four similar balks of the same quality at the bottom of the sinking pit. The balks at the bottom would extend into the sides for a certain distance over the ordinary diameter of the shaft. From the balks on the surface I would attach chains or wire ropes of good quality, which would hang down the shaft. The other end of the ropes or chains would be attached to the balks at the bottom of the shaft. The walling curb could now be fixed upon the balks, having been prepared to receive it, and the walling built up to the surface. The walling would now be supported by balks let in the strata at the bottom, and further supported by chains or ropes, by balks from the surface.

When proceeding with the sinking below the curb, I would take further precautions by not allowing blasting to be done for a certain distance below the curb. As soon as the bad ground was gone through, and some hard or solid strata were encountered, I would give instructions for another walling curb to be put in upon a solid foundation. From this curb the walling could be connected to the last, and the balks cut out if desired.

Supposing the bad ground was encountered after a certain length of walling had been put in, I would adopt this method of fixing and supporting the walling curb, as the balks for supporting the chains, &c., could be let into the sides of the shaft above the last permanent walling curb.

Having fixed a walling curb and supported it by this method, I would continue to make periodical examinations of the foundation and everything in connection with the curb, so as to guard against any mishap befalling the sinkers from the walling above as the sinking proceeds. I would interfere with the strata in close proximity with the balks supporting the curb as little



Illustrating Question 4.

as possible, when sinking immediately below, and refrain from blasting altogether until a hard stonehead was reached, so as not to disturb the curb or damage the ropes or chains supporting it.

By taking the above precautions I believe the walling can be accomplished permanently, with satisfaction and with safety.

Thos. Gaskell, 138, Downall Green Road, Bryn.

[NOTE.—Strange to say, many competitors, in answering this question, took no more notice of the mention of bad ground than if they had been asked to describe the laying of a ring on solid rock. It is absolutely essential that the curb should be as rigid as possible while being built upon, and until it is bricked up to from below it is necessary to adopt special methods, seeing that it has to be laid in bad ground. For slinging the ring from the one above we should prefer chains to ropes, as being likely to give less than ropes on receiving the increasing weight of the brickwork.—C.C.M.]

C. Simpson, F. Mitchard, E. R. Hindle, W. Williams, S. F. Middup, S. Beardsley (*12 marks each*).

J. C. Rodman, G. H. Fearn, L. J. Thomas (*8 marks each*).

SECOND CLASS.

Methods of Working.

Q. 5.—*What would guide you as to the length of a wall face in working a seam of 3 feet thick and under?*

A.—When determining the length of a long wall face it is obvious that we must first of all consider a number of very important points. Each seam possesses its own individual peculiarities, and must be considered accordingly. With this system of working instances could be given where the length of wall ran up to hundreds of yards, even a mile in some cases. Naturally, the general shape of the face will also influence to some extent the length of working. Sometimes it is stepped, straight, or perhaps a system of curvilinear working is employed, in which case the coal does not usually contain any definite cleavage planes, and is therefore similar, as regards ease of working or hewing, when worked with or against the "slips." The chief considerations are: (1) Required output; (2) haulage requirements; (3) nature of seam; (4) thickness of seam; (5) future developments. Of course, there are usually other conditions, of a local nature, which go to govern the length of face. For instance, the existence of faults, wash-outs, and intrusions of igneous rock always limits the distance of the face. This is the chief reason why long wall is not suitable in a seam greatly cut up by faults, &c. Generally, the length of face is mainly governed by the required output.

Example.—What length of face is necessary to gain an output of 400 tons in an eight hours' shift, assuming that one workman can fill 3 tons per shift?

The number of miners required would be, say 134; then, if three work in each stall the number of stalls would be 44 or 45.

In a seam 3 feet thick, the length of face per man averages about 5 yards, therefore the required length of face is 134 × 5 = 670 yards. The length will vary inversely as the thickness of the seam. Our great aim should be to have the shortest length of face possible, and the greater number of men that can be put to work in any given length of face the greater are the advantages, *i.e.*, the men can be placed closer together, and as the length of face allotted to each man does not usually exceed from 4 to 5 yards, the maximum output can be secured with the least possible length of face. The advantages so gained are: (1) The men being close together, and not scattered all over the mine, the problem of ventilation is not so difficult, as its circuit and resistances are not so great; (2) the face worked is rapidly driven forward, and is consequently a boon when a bad roof is present; (3) the haulage roads being anything from 30 to 40 yards apart, are few in number, and therefore less roads are required to be maintained in repair; (4) the goaves being few are in a better position to be efficiently packed and secured. Advantage (3) is of special importance, especially if the seam is under 3 feet in thickness, in which case it is too thin to admit of haulage along the face, except with conveyors. Therefore, I should always endeavour to ensure the minimum of face and stall roads consistent with facility of working and safety to the workmen. By having unduly long and extended walls nothing is gained, but in most cases a great deal is lost. The upkeep of the roads would be expensive, while the course of the air current is unnecessarily long and attended with difficulties. If it is required to maintain a high output the length of wall may be gradually increased as found necessary. Another factor which sometimes influences this question is the amount of rubbish at disposal for packing the wastes. The packs should be as solid as possible, as great trouble is often experienced through building loose and untidy packs, which often give way at the least indication of a "weight." Other points of interest are:—

1.—Long and extended walls simply mean lost time by the haulier in changing a tram of coal at a distant working place.

2.—If the seam is thin, with a consequent necessity of "rippings" of roof or floor so as to maintain height for haulage purposes, the length of face is arranged to just allow a sufficient space to stow the stone produced by the rippings, in addition to any rubbish yielded by the seam.

3.—With a short face, and hence the minimum of stall roads, the rails, sleepers, &c., are in full employ, and are not allowed to deteriorate as would otherwise be the case.

4.—A disadvantage accompanying a long face is, that the miners having a greater length of face, are more liable to create projections of coal, usually just between two stall roads, and these "bunches" render machine cutting almost impossible and form an impediment to the air current.

A. Nelson, Maes-y-Dyffryn, Glyn Neath, Glamorgan.

[NOTE.—This is not by any means an easy question to which to find a definite answer. Presumably the desire and aim of every colliery manager, in working long wall, is to have

as long and as straight a face as he can obtain and keep open. We are at present connected with a colliery with one face of considerably over a mile in length and practically straight, which would be a mile and a half if a nasty fault had not intervened, though in this case the coal is nearer five feet thick than three. We should say that we should be guided as to the length of a wall face by having it of as great a length as would allow of its being carried forward without any falls other than purely local ones.—C.C.M.]

E. Ambrose, R. Graham, R. Morgan, A. Stephens, J. A. Withington, J. Grundy (*12 marks each*).

W. A. Onley, A. Harrison (*8 marks each*).

Timbering.

Q. 6.—*Sketch the various systems of timbering with which you are acquainted, and briefly explain the circumstances suitable to each.*

A.—In the sketches are shown the various systems of timbering adopted in our mines. *Figures 1—8* show the different methods of timbering main roads. Where there is a strong roof with substantial pillars of coal on both sides of the main roads the method of timbering shown in *Figure 1* may be adopted to advantage; as will be seen in sketch, the bar is let into notches at each side of the road. *Figure 2* shows the method of securing the roof where span of the road is wide, and the sides are not strong enough to hold the bar, as in *Figure 1*. Where the roof is crumbly and broken up, sides of old wagons are laid upon the bars from bar to bar to prevent the *debris* falling on the roadways. See *Figures 3* and *6*. Where the sides are of a crumbly nature laggings are placed between the bar-legs and the sides from one leg to another (*Figure 4*) to prevent *debris* rolling in the road. *Figure 5* shows methods of timbering where there is great top weight and side pressure. *Figure 7*, method of timbering called cockering, which is adopted in some of the Lancashire collieries. This method will resist very great top and side pressure. *Figure 8* is a method adopted to resist great pressure from floor, roof, and sides. *Figures 9* and *10* show methods of timbering the colliers' places in the long wall with props, split bars, and chocks, and also the methods of supporting the coal. Tapered props are sometimes used to advantage at the coal face, especially where the roof and floor are very strong.

Slightly indebted to back numbers of this Journal.

E. Ambrose, 28, Trinity Street, Rhostyllen, near Wrexham.

G. Browne, A. Nelson, A. Stephens, J. Grundy (*12 marks each*).

R. Morgan (*8 marks*).

Ventilation.

Q. 7.—*Give the rule and an example in estimating the work done in ventilation at a colliery by a fan.*

A.—To do work we must either raise work against gravity or overcome resistance. When a colliery fan produces a difference in pressure, and this causes the air to travel through the mine, it is said to be doing work. In doing work the effort exerted must be equal to the resistance overcome, and this effort must be exerted through space, or distance. Therefore

Work done = resistance overcome × distance in feet.

Now, p = pressure in lb. per square foot;

a = area in square feet;

v = velocity in feet per minute.

Then pa = total pressure produced = total resistance overcome;

v = space in feet per minute.

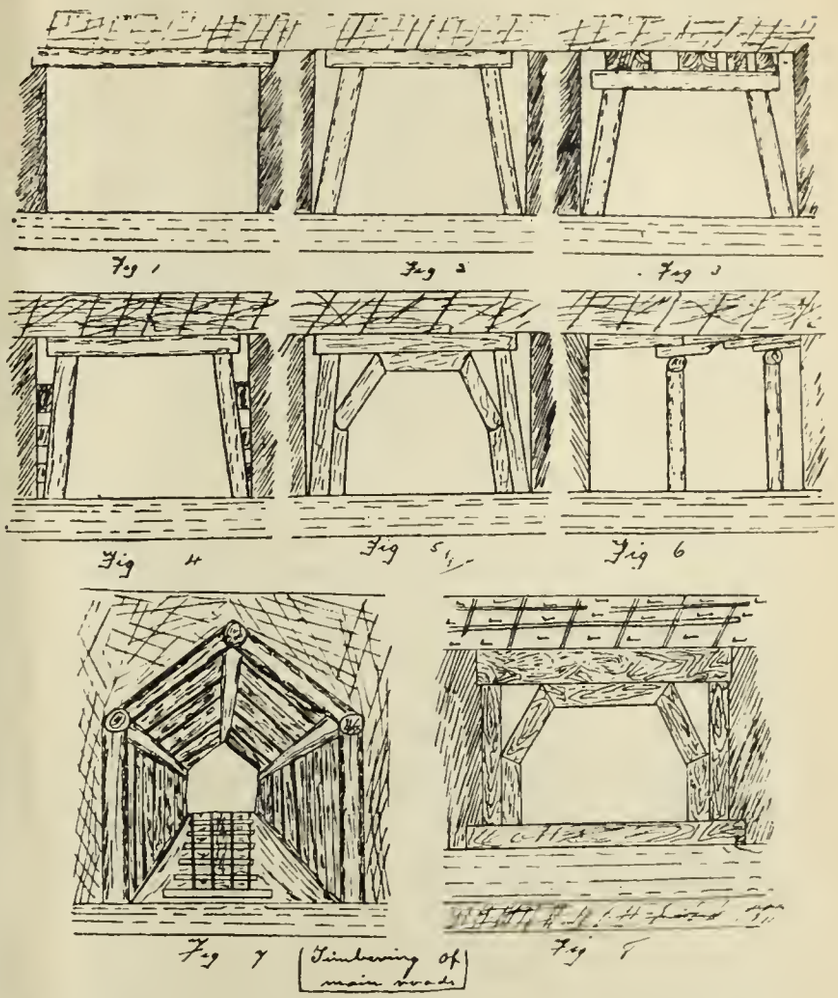
$\therefore p \times a \times v$ = foot-lb. of work done in one minute.

$$\therefore \text{H.P. in air} = \frac{pav}{33000}.$$

$$\therefore \text{Since } a \times v = \text{quantity, } q. \quad \text{H.P. in air} = \frac{pq}{33000}.$$

Again p = W.G. in inches × 5·2.

$$\therefore \text{H.P. in air} = \frac{q \times \text{W.G.} \times 5{\cdot}2}{33000}.$$



Illustrating Question 6.

Example.—Suppose 100,000 cubic feet per minute is passing through a road with 2 inches W.G. Find H.P. in the air.

$$\text{H.P. in air} = \frac{100000 \times 2 \times 5{\cdot}2}{33000} = 31{\cdot}5.$$

The useful effect of a fan is the amount of beneficial work obtained out of the fan engine. To calculate this we must first find the horse-power of the fan engine.

To do this we work by the rule $\frac{PLAN}{33000}$.

When P = pressure of steam effective in lb. per square inch;
L = length of stroke in feet;
A = area of cylinder;
N = number of strokes per minute.

Example.—Suppose the diameter of cylinder is 20 inches. Steam pressure 30lb., 3 feet stroke, and 80 strokes per minute.

$$\text{H.P.} = \frac{30 \times 3 \times 20^2 \times \cdot7854 \times 80}{33000} = 68\cdot8, \text{ say } 69.$$

It will be seen by the above example that the H.P. in the air is only a part of the whole I.H.P. of the engine driving the ventilation.

Therefore, the percentage of useful effect being shown by

$$\frac{\text{H.P. in air} \times 100}{\text{I.H.P. of fan engine}}.$$

$$\therefore \frac{31\cdot5 \times 100}{69} = 45\cdot8\ \%.$$

Indebted to back number of this Journal for assistance.

JOSEPH GARNER, 62, Mountain Street, Rhos.

E. Ambrose, A. Nelson, J. Cheetham, A. Stephens, J. A. Withington, J. Grundy (*12 marks each*).

A. Harrison, R. Morgan, A. Turner, W. C. James, R. Graham (*8 marks each*).

Pumps and Pumping.

Q. 8.—*What diameter of pump will be required to deal with 500 gallons of water per minute, allowing 10 per cent. for leakage, if the effective speed of the pump is 35 feet per minute?*

A.—The size of pump required can be found by dividing the number of gallons by ·034 × speed of pump.

$$D^2 = \frac{500}{\cdot034 \times 35} = \sqrt{420\cdot168}.$$

Ten per cent. is to be allowed for leakage, and since the pump has to deal with 500 gallons per minute, the slip must be added to the 500.

$$\therefore \frac{500 \times 100}{90} = 555\cdot555.$$

Now, by repeating the above process we have

$$\frac{555\cdot555}{\cdot034 \times 35} = 21\cdot6 \text{ inches diameter of pump.—}\textit{Answer.}$$

Robert Morgan, Bryn Rhosyn, Bagillt.

[NOTE.—The answer to this question was arrived at correctly by most competitors except those who assumed that more than one pump was employed. According to the question, the diameter of one pump to do the work was required. Neither are we justified in adopting a pump to pump 24 hours in 16 hours or 12 hours, but just to find what size will be required to deal with the quantity under discussion at the given effective speed, simply making an allowance of 10 per cent. for leakage. In making this allowance one or two competitors erred slightly. If we assume that a pump loses 10 per cent. of the water that means that if she lifts 100 gallons she only delivers at the surface 90 gallons, or, in other words, to deliver 90 gallons she must be made large enough to lift 100. Now, 100 is 10 more than 90, or one-ninth of ninety more, so that if we want a pump to deliver 500 gallons per minute it must be made capable of lifting one-ninth of 500 more than 500, equals a total of $555\frac{5}{9}$ gallons. If we allow 10 per cent., or one-tenth of this off for leakage, we shall find that what is left is exactly 500 gallons. It may appear at first sight a small point, and only very slightly affects the answer, but it is a small point like this which often counts in an examination.—C.C.M.]

A. Stephens, T. J. Hay, A. Harrison, W. A. Onley, J. A. Withington, P. Wilson, J. Grundy, R. Benson, R. Graham, E. Ambrose, A. Nelson, W. C. James (*12 marks each*).

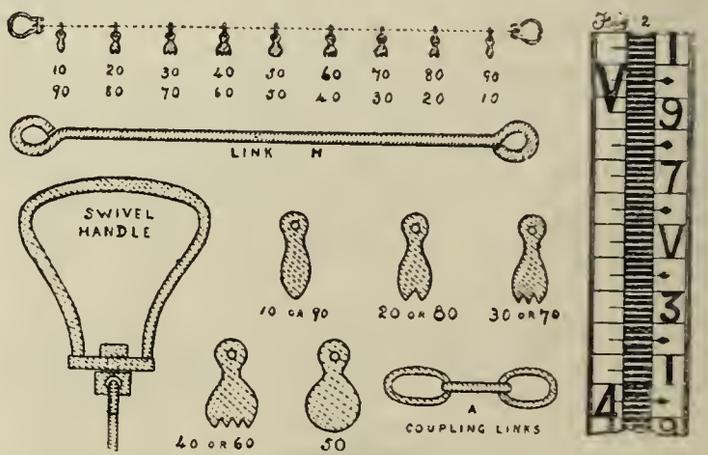
J. Cheetham, H. Taylor, A. E. Helps (*8 marks each*).

FIRST CLASS.

Surveying.

Q. 9.—*Describe a level chain and levelling staff. State for what each is used and the means you would adopt for testing the chain.*

A.—The chain is undoubtedly one of the most important surveying instruments used. It was invented by Edmund Gunter, Prof. of Astronomy, in 1620, and practically exists at the present day in its original form. A Gunter's Chain is made either of steel or iron wire, with brass tags or counters and brass handles. The best form of chain is one in which the counters are arranged as shown in sketch. The chain is 22 yards in length, and is divided into 100 links, so that including the joining links shown at (*A*) the length of each straight link is 7·92 inches. Each link is bent into the form of a ring at the ends, and each link (*H*) is joined to the neighbouring links by small coupling links. At every tenth division or link, a small counter of brass is attached, and the number of tens from each end of the chain is known by the shape of the counter. For instance, the 10th and 90th links are indicated by a brass counter with 1 point, 20th and 80th links by a counter with 2 points, 30th and 70th links with 3 points on counter, and 40th and 60th by a counter possessing 4 points. The 50th link is easily recognised by a counter of entirely different shape, the counter being rounded off at the bottom. To prevent the chain from becoming kinked swivel handles are provided, and I may mention that a chain I have commonly used has a swivel at the 50th link. Practically speaking, the length of the straight link (*H*) is not 7·92 inches, the length of link including the three small coupling links. The method of construction and reading may be seen from the sketches.



Illustrating Question 9.

When using the chain it is easy to detect mistakes from misreading the 10th and 90th, 20th or 80th, 30th or 70th links, by judging the distance with the eye, but in the case of the 40th and 60th links mistakes may be very easily made. Personally, in every case of doubt, I refer to the 50th link, and from its position the correct number of links can be accurately read. It should be stated that the handles are included in the length of the chain. By arranging the counters in this way the chain may be read from either end.

A Gunter's Chain is used for several purposes. Chiefly it is used for the measuring of sight lines, &c., or for the purpose of facilitating the approximate computation of areas (since 10 square chains = 1 acre). The chain may be also used for setting out a right-angled triangle, or for levelling purposes on low gradients when used in conjunction with a plumb line.

Levelling Staff.—A levelling staff is a very important part of the surveyor's equipment. The staff is of various forms, but in every case it is designed in such a way as regards gradations that the heights are read off by the instrument to a very small fraction of a foot. The levelling staff usually consists of three parts which slide one within the other, and when opened out for use form a staff 14 to 16 feet in length. The staff most frequently used is that known as a Sopwith staff, an enlarged portion being shown in *Figure 2*. In this form of staff the feet are represented by large red figures, the tenths are represented by odd black figures, and the hundredths are coloured

alternately black and white. Between the odd figures representing tenths a black diamond is painted to indicate the alternate five-hundredths, as shown in the right-hand column. The red figures denoting the feet are placed in the left-hand column, and the black figures representing the tenths of a foot are placed in the right-hand column as shown. It will be seen that the even numbers are omitted, the idea being to proportionately increase the size of the odd figures so that they may be read at greater distances.

The top of every figure denotes its value. Of the black and white divisions, the bottom of each black space represents odd hundredths, the top even hundredths. This staff is usually 14 feet in length, and divided into three parts, which when drawn out are held in position by a spring clip at the back. When closed they form a staff about 5 feet 3 inches in length, 3 inches wide, and 1½ inches deep. The inverted image of the staff when looked at through the lens of the instrument is apt, till the observer becomes experienced, to cause mistakes to be made. On some forms of staffs the numbers are inverted when painted on the staff. For levelling underground staves may be employed similar in construction to those used on the surface, except that obviously they must be shorter. The best sizes are a 9-foot Sopwith's staff to close down to 3 feet 6 inches, or a 6-foot Sopwith's staff to close down to 2 feet 6 inches. The difficulty is to light up the staff sufficiently to admit of accurate readings. To overcome this objection, a reflecting candle or safety-lamp holder is used, which can be slid up or down the staff as required.

A useful staff for colliery work has been designed by Mr. G. J. Gee. It consists of three lengths, sliding one into the other. The bottom length is graduated upwards, and forms an accurate continuation of the scale on the lower division of the staff. The band passes over a brass roller attached to the top division of the staff, and thence is carried down and wound round a small brass drum, fixed just below the roller, to the top of the same length of the staff, the band being kept in tension by means of a box spring attached on one side to the axis of the cylinder. It is thus evident that when the second length of the staff is drawn out, the band unwinds and gives a continuous reading up to 5 feet 8 inches, or to any intermediate distance that the height of the roof will allow. In the same way when the third length is drawn out, a continuous reading may be obtained up to 9 feet or to any intermediate distance required. The weight of the staff is 5lb., so that it is very portable for underground use especially.

Levelling may be said to be the art of determining the relative distance of points from the centre of the earth. One point is said to be above another when it is farther from the centre of the earth, and the difference of distance of that centre is called the difference of level between the two points. A levelling staff is used for the purpose of estimating the difference of level.

Testing the Chain.—It must be remembered that any error in the length of the chain will cause erroneous measurement throughout the entire survey. It should, therefore, be tested and adjusted before the commencement of every survey, or at any rate from time to time. This is best done by having a standard marked on a level pathway, or on the top of a wall, showing not only the accurate length of the chain, but also the length of every ten links. Standard 66 feet and 100 feet chains have been fixed by the Government in Trafalgar Square and Guildhall for the use of surveyors. It would, of course, be impracticable to test every chain in this way before a survey. The best plan is, in my opinion, to obtain a chain of guaranteed correct length, and to lay down its length upon a wall or some similar place as suggested above, near to the shaft mouth. It would thus be easy to test the chain at any time when required.

When estimating the area of a field by a chain which is *too short*, it is obvious that the ultimate area obtained would be incorrect, *i.e.*, the area would be *too large*. If a chain is used which is appreciably greater than the correct length, the area of the field which has been calculated by this chain, would be *too small*.

If a line has been measured with an incorrect chain, the true length of the line may be found from the proportion:—As the length of the standard given by the incorrect chain is to the true length of the standard, so is the length of the line given by the measurement to its true length.

Indebted for part of this answer to BROUGH'S *Surveying*.

W. HEYS, 1, Walter Street, Huncoat, Accrington.

F. Hutchinson, W. Silverwood (*12 marks each*).

Tipplers.

Q. 10.—*Describe one modern type of automatic tippler, showing the method of operating it.*

A.—The tippler shown in sketch is one made by Messrs. Joseph Cook and Sons, Durham, and is called "Cook and Hobson's Patent Automatic Tippler." It is one that works automatically. The loaded mine wagon, on entering, releases the empty one, and is itself held fast, the tippler starting and stopping without attention. It is built with cast-steel rings framed together with the bars. These rings fit the grooves in the friction rollers *A* and *B*. Two of the friction wheels marked *A* in *Figure 1*, are keyed on to the driving shaft, and the rings are driven by them whenever they rest upon them. The rollers on the other side, marked *B*, are loose rollers to support the rings and allow them to turn freely. When the tippler is at rest the rings are supported on one side by the loose rollers *B*, and on the other side by a pair of cast-steel brackets marked *C*, one under each ring. These brackets are supported by the eccentric shaft *D*, so that the rings are ⅛-inch clear of the friction wheels *A* when the tippler is at rest.

As the full tub enters the tippler in the direction of the arrow the front axle depresses the lever *E*, which works the stopper *F* through the two levers G_1, G_2. The lever G_1 works on a pivot under the platform, and carries a weight *W*, which tends to raise *E*. The other lever G_2 is carried by the revolving part of the tippler, and the scarfed end of it overlaps the end of G_1 when the tippler is at rest. A spiral spring (*Figure 2*) under the outer end of G_2 keeps it and the stopper in the position shown.

After the stopper *F* is depressed by the full tub, the latter pushes out the empty tub, keeping the stopper down until the empty tub is clear. After the last axle of the empty tub has passed over the stopper *F*, the full tub has advanced so far as to release the lever *E*, with the result that the stopper resumes its first position and keeps the full tub in its place. The empty tub being clear of the tippler ring strikes the lever *H*, which, by a system of connected levers, works the eccentric shaft *D*, and allows the brackets *C* to fall, thus bringing the rings into contact with the friction wheels *A*, and immediately starting the tippler.

The lever *H* is connected to a weight shaft which carries a counter-weight W_2, as shown. This causes the lever *H* to rise, and the brackets *C* to resume their original position, as shown, as the empty tub has passed. When the tippler returns to the upright position the projections on the sides of the rings run up on to the brackets *C*, and so lift the rings clear of the friction wheels, and the tippler is stopped.

Thus it is unnecessary for anyone to be at the tippler, and in a large plant there is a considerable saving of labour, a larger output can be handled, and no time is lost in waiting for anyone to start the tippler.

Assisted by BOULTON'S *Practical Coal Mining*.

W. T. HUGHES, 103, Wigan Road, Ashton-in-Makerfield.

W. Heys, F. Hutchinson (*12 marks each*).

Ventilation.

Q. 11.—*What means would you adopt to ascertain if the ventilation of a mine, working with naked lights, was adequate?*

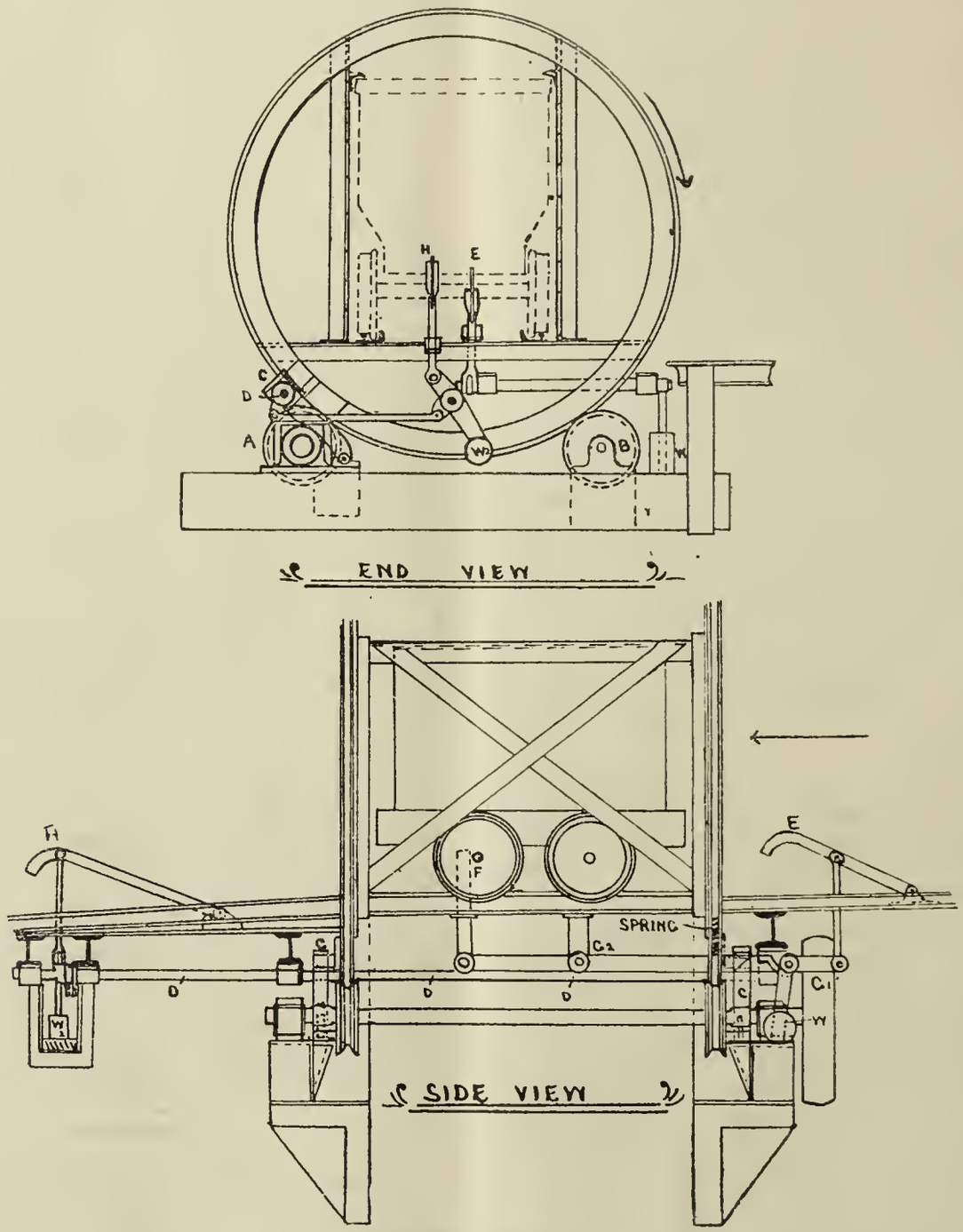
A.—One of the most important factors in the successful working of coal mines is undoubtedly that of the proper ventilation of the roadways, working places, &c. It is absolutely essential for the safety and comfort of the persons working in the mine to constantly provide an adequate amount of fresh air in such quantities as to comply with the 1st General Rule. If the requirements of the above rule are not fully complied with, then the ventilation of any mine, whether worked by naked lights or safety-lamps, is not adequate. When it is desired to examine into the state of the ventilation, it would be well if the persons making the investigation would keep in mind the above rule, and take it as a standard.

In my opinion it is impossible to attempt to correctly judge

the standard of the ventilation by the supply of air generated by the fan, chiefly owing to the improper distribution and conduction of the air throughout the workings, and also owing to the loss of air by leakages, &c. Of course, with a good ventilating plant which possesses a reserve of power, and where there is plenty of air available, the ventilation of a mine by separate splits is not a serious problem, especially if each split has not an extensive area to ventilate. When the workings become extensive great care and attention are needed to keep the ventilation up to the required standard. The air must necessarily traverse a more circuitous route, owing to which more leakages may be expected. Again, in addition to the face workings very often extensive abandoned areas have to be kept adequately ventilated, and this, coupled with the addition of the various splits and the more serious amount of leakages, the quantity of air passing in each split may very easily approach the minimum quantity necessary to provide adequate ventilation. In a case of this description it will be easily seen that it would be advantageous to consider each split in turn, and determine as carefully as possible which splits are not adequately ventilated, and which may be adequately ventilated by taking away a proportion of the air. In this way one split may compensate another without unduly interfering with the ventilating arrangements. The anemometer would be a useful appliance to use in cases of this description. In addition to measuring the quantity of air passing in the respective splits, attention must be paid to the *quality*.

The persons making the investigation should pay special attention to the following points :—

(1) The condition of the workings as regards the presence of noxious gases.



Illustrating Question 10.

(2) The quality of the return air-current in the various splits and main return.

(3) The velocity of the air in the workings.

(4) The temperature of the mine atmosphere.

As an example of investigations made as to the conditions of the ventilation the following report may be of interest. The investigation was made by the Fairmont Coal Company, this systematic investigation having now become a useful and permanent feature. The investigations and reports cover the

total quantity of air in circulation in the mine, the quantity in each respective split, the relative humidity of the outside atmosphere, the main intake, main return, and the intake and return of each split, and the percentage of carbonic acid gas or fire-damp in the main air-current and in each split.

For an investigation of this description the instruments needed would be water-gauge, anemometer, thermometer, hygrometer, sampling cans for the analyses, and also a safety-lamp.

Assuming I had to investigate as to the condition of the ventilation, I would first deal with the splits as mentioned in a previous part of this answer. A careful inspection should then be made with a good safety-lamp, taking care to examine all doubtful accessible places, such as goaf edges, holes in return air-roads, &c. If a "cap" showed the ventilation would not be adequate, since it has been proved that a smaller amount of gas than an ordinary safety-lamp could detect (say 2 per cent.) is explosive in the presence of coal dust. I mention fire-damp tests because, in my opinion, no mine, even though worked with naked lights, is altogether free from fire-damp.

I should then proceed to the returns in the various splits, and also the main return, and test for fire-damp with the safety-lamp. This test is far more important than the previous test, as it gives the condition of the various splits, and also the main return, *i.e.*, the condition of the ventilation in the whole mine. The velocity at which the air is moving is an important point to consider, the anemometer coming in very handy for this object. If the velocity of the air-current was too sluggish to remove the noxious gases, then the ventilation would not be up to the required standard. The gases from explosives should be readily removed, because these are injurious to the health of the workmen.

The temperature of the mine workings will be an important feature of modern mining. It should be maintained so as to enable the workmen to discharge their duties with a reasonable amount of comfort. The thermometer should be used to register the temperature, and the ventilation raised when the thermometer shows a high reading.

In naked light pits fire-damp is seldom present in appreciable quantities, but whilst the percentage of fire-damp can be readily estimated by means of a "cap" on the flame of a safety-lamp, no equally simple test has hitherto been available for estimating the amount of black-damp in the air. A rough idea can doubtless be formed from the dulness of the flame, and also the effect upon the breathing; but until recently some more definite method, short of an actual chemical analysis, was much needed. When air is mixed with black-damp the oxygen percentage of the air is lowered in proportion to the amount of black-damp added. The percentage diminution in the oxygen is thus a measure of the percentage of black-damp, that is, unless fire-damp or some other gas is present in an appreciable amount and helps to lower the oxygen. In naked light pits, fire-damp is seldom, however, present in appreciable quantities, so that deficiency of oxygen is, practically speaking, a measure of the percentage of black-damp. A flame test can thus be graduated either to percentages of oxygen, or to percentages of black-damp.

The apparatus by which a test can be performed consists of a piece of glass tube and some tapers, the tapers used being $\frac{1}{16}$th of an inch diameter. When a lighted taper is held inside the tube an upward draught is, of course, produced by the heat, and this draught varies in strength according as the taper is held high or low down in the tube. The draught tends naturally to blow the flame out, and, according to the percentage of oxygen in the air, the flame is extinguished at a point lower down or higher up in the tube. The size of the tube chosen as being convenient for the test is one 7 inches long by 0·75 inch internal diameter. The main graduations are in percentages of black-damp from 0 up to $10\frac{1}{2}$, and there are subsidiary corresponding graduations in percentages of oxygen from the normal of 20·9 down to 18·8. Below about this percentage the taper will no longer burn in the tube, and when held upright it will no longer burn outside the tube with less than about 18·2 per cent. of oxygen or 13 per cent. of black-damp; but, when held in a horizontal position it will burn until the percentage of oxygen has fallen to about 18 per cent. of black-damp. There is thus a wide range within which the proportion of black-damp can be estimated by the taper and tube.

In this way the ventilation in a naked light mine can be investigated, but, if thought preferable, samples of the return air can be taken at points selected in the return air-ways in order to ascertain the maximum percentage of noxious gases carried by the air.

It may be interesting to note that in the Coal Mines Act, 1911 (which will shortly come into operation) a place shall not be deemed to be in a fit state for working or passing therein if the air contains either less than 19 per cent of oxygen or more than $1\frac{1}{4}$ per cent. of carbon dioxide, and an intake air-way shall not be normally kept free from inflammable gas if the average percentage of inflammable gas found in six samples of air taken by an inspector in the air-current in that air-way at intervals of not less than a fortnight, exceeds one-quarter.

Taking this as a standard, I should conclude that the mine was not adequately ventilated if the regulations of the above were not carried out.

Rules have been theoretically framed for the fixing of an adequate amount of air per man, horse, lamp, &c., in fiery or non-fiery mines. Seeing that all mining authorities differ as to the exact theoretical amount of air necessary, and that the conditions existing underground vary in almost every mine, such rules are, to say the least, misleading, and not to be relied upon for the efficient ventilation of modern mines.

Indebted for part of the above answer to papers read before the West Virginian Coal Mining Institute, and also the Institution of Mining Engineers.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

[Note.—The question of the amount of air passing as measured by an anemometer hardly arises in answering this question. No matter how much air was passing, if there was gas lodging in places, or gas caps to be discovered in the returns, we should not say that the ventilation was adequate. If the returns were all free from any appearance of a cap, and there was no gas lodging in the higher sides or goaves, and the workings and faces were not unduly hot, then we should say that the ventilation was adequate, no matter whether there was 500 cubic feet or only 50 cubic feet per man per minute.

In our own opinion it is most fallacious to base an opinion as to the adequacy or otherwise of a ventilation current on the number of cubic feet per minute passing per man, or on the quantity passing per ton of coal raised. Some mines are better ventilated with a current of air allowing 100 cubic feet per man than are others where the quantity works out to double or even treble that quantity.—C.C.M.]

W. T. Hughes, F. Hutchinson (*12 marks each*).

Pumps and Pumping.

Q. 12.—*Sketch a pump for raising 6,000 gallons per hour through a vertical height of 160 yards, and give principal dimensions.*

A.—To deal with this question in a practical manner, there must be installed a pumping plant fully capable of dealing with the feeder, and at the same time allow a safe margin for any increase in the feeder. Allowance must also be made for stoppages, breakdowns, and repairs, therefore we must install a plant to deal with 24 hours' water, say in 16 hours (two eight-hour shifts), *i.e.*, a pumping plant capable of dealing with 9,000 gallons per hour.

Personally, in accordance with modern tendency, I should prefer to install some form of electrically-driven pump, giving preference to the treble-ram or three-throw pump. The three-throw pump is a very strong one, is simple, and does not easily get out of repair. As may be gathered from the name, there are three rams and three working barrels, each separate ram making one backward and one forward stroke during each revolution of the crank shaft. The rams are set at an angle of 120° in advance of each other, so that at no portion of a revolution can all three rams be drawing or pumping water simultaneously. For instance, either two rams will be pumping water while the other is drawing its water, or one ram will be pumping while the other two are drawing. In this arrangement each ram is provided with a separate suction pipe, but all three suctions are connected by a horizontal suction pipe to each other, the horizontal pipe being just immediately above the snore piece. This arrangement ensures the three suctions being kept equally filled with water. The clacks are generally of the mushroom

variety, but frequently a kind of double-beat clack working on a fixed central spindle is preferred. After passing through the delivery clacks the water passes through three short delivery connections into a common rising main through which it reaches the shaft bottom or surface as the case may be. An air vessel is usually provided to equalise the flow of water, prevent shocks &c. The action of the pump is similar to the ordinary plunger type; the three cranks being set at an angle of 120° in advance of each other ensures a steady flow of water in the delivery. This arrangement enhances the efficiency of the pump, and reduces the shock and the wear and tear on the working parts to a minimum. As this pump works at a comparatively low speed, it has to be geared down owing to the high speed of the motor. The gearing is usually machine cut, raw-hide pinion for the first motion, and double helical for the second motion; or as an alternative spur gearing.

In the pump shown in sketch the diameter of the main driving shaft is three inches, of the smaller gear pinion 1 foot 1 inch, of larger helical gear wheel 3 feet 3 inches, the ratio being, therefore, 3 to 1. Revolutions of crank shaft 48 per minute, and taking the pump as being single-acting the effective speed of the rams is 48 feet per minute.

Dimensions of Pumping Plant.—Assuming length of stroke as 12 inches, then size of rams required:—

Where D = diameter of each ram in inches; S = speed of rams in feet per minute; N = number of rams; G = gallons pumped per minute.

$$D = \sqrt{\frac{G}{S \times \cdot034 \times N}} = \sqrt{\frac{150}{48 \times \cdot034 \times 3}} = \sqrt{\frac{150}{4\cdot896}}$$

= 5½ inches (approximately).

Size of Suction and Delivery Pipes.—The pipes should always be of such dimensions as to reduce the velocity of water in the pipes to a reasonable amount. It is desirable that this should not be greater than 200 feet per minute.

$$\text{Cubic feet of water per min.} = \frac{\text{Gallons per minute}}{\text{Gallons per cubic foot}} = \frac{150}{6\cdot25} = 24.$$

$$\text{Area of pipe in square feet} = \frac{\text{Quantity}}{\text{Velocity}} = \frac{24}{200} = \cdot12 \text{ sq. foot.}$$

Area of pipe in square inches ·12 × 144 = 17·28 square inches.

$$\therefore \text{Diameter of pipe} = \sqrt{\frac{17\cdot28}{\cdot7854}} = 4\cdot75 \text{ inches (approx.)}$$

Thickness of Metal in Pipes.—The thickness of cast-iron pipes should be so calculated as to allow for a good margin of safety, or safety factor (say 10), and also to allow for shocks and sudden variations of pressure in the pipes.

Where T = thickness of metal in pipes in inches; H = head in vertical feet; P = pressure in lb. per square inch; factor of safety F; D = diameter of pipes; B = bursting pressure of cast-iron

$$\text{Then } T = \frac{H \times P \times D \times F}{B \times 2} = \frac{480 \times \cdot434 \times 4\cdot75 \times 10}{18500 \times 2} = \cdot27''.$$

Having obtained particulars of pump, pipes, &c., we will now determine the necessary power to work the pump. Assuming an efficiency of 70 per cent., then the H.P. of motor

Where H = head in vertical feet; 10 = number of lb. in 1 gallon; G = number of gallons to be pumped per minute.

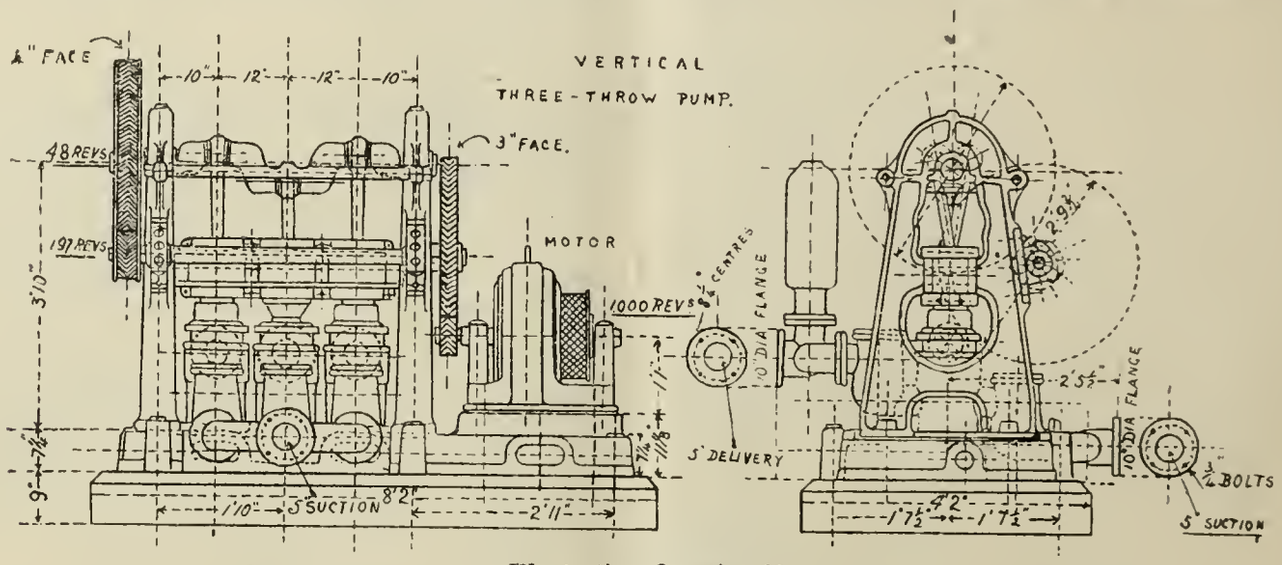
Then H.P. of motor

$$= \frac{G \times 10 \times H \times 100}{33000 \times 70} = \frac{150 \times 10 \times 480 \times 100}{33000 \times 70} = 31\cdot15 \text{ H.P.}$$

Assuming the voltage as 500, then volts × amperes = watts, and 746 watts = 1 Electrical Horse-Power. So that watts ÷ 746 = E.H.P.

$$\therefore \text{Amperes} = \frac{\text{Watts}}{\text{Volts}} = \frac{31\cdot15 \times 746}{500} = 46\cdot47 \text{ (nearly).}$$

Size of Cables.—The loss of pressure in the cables depends upon their size and length, and also to a certain extent upon the number of amperes carried per square inch sectional area of copper. The usual allowance of area is at the rate of one square inch of copper for a current of 1,000 amperes; at this density the drop or loss in pressure in the cables is 2·5 volts for every 100 yards in length of the conductor.



Illustrating Question 12.

$$\text{Area of cable in square inches} = \frac{46\cdot47}{1000} = \sqrt{\cdot04647} = \cdot216 \text{ sq. in.}$$

·216 ÷ ·7854 = ·275 inch diameter.

To find the drop or loss in voltage in the cable due to transmission we must calculate the total length of the cables (positive and negative) which in this case is equal to 320 yards. Seeing that the drop per 100 yards for a current of 1,000 amperes per square inch equals 2·5 volts = 2·5 × 1·6 = 4 volts. Therefore, to maintain a voltage of 500 at the motor, the pressure at the dynamo must be maintained at 504 volts.

Adequate lodge room should be provided so as to be adequately prepared for a serious breakdown, that is, two day's water, or allowing pumps to stop 48 hours. Therefore, 48 × 60 × 150 = 432,000 gallons lodge room should be capable of holding.

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[NOTE.—This is a question in answering which it is necessary to pay more attention to the sketch than to the written answer. In fact, it would have been quite possible for a sketch alone to have gained selection provided it was properly dimensioned, without any written matter or worked out calculations, provided, of course, that the size of the pump corresponded to the requirements of the question.—C.C.M.]

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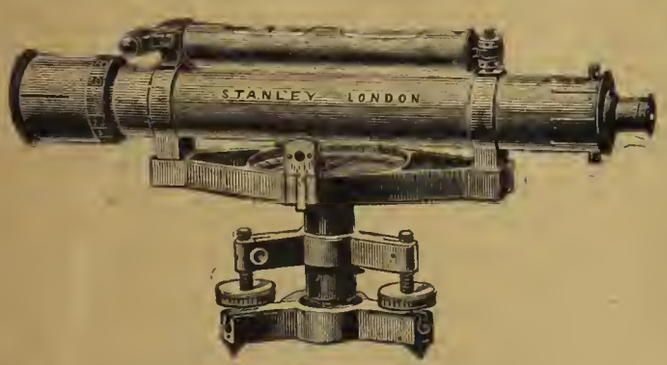

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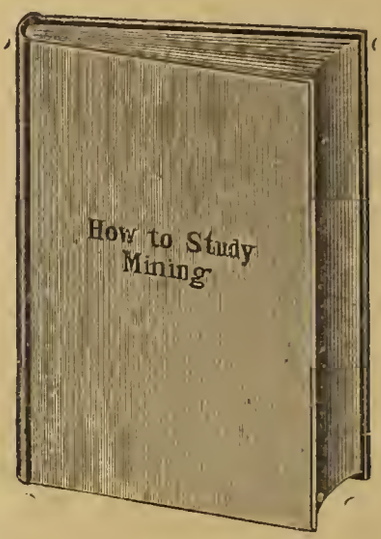

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The Science and Art of Mining.

VOL. XXII.—No. 22.] SATURDAY, JUNE 8, 1912. [PRICE 3d.

NEWS AND NOTES.

Chinese Miners.

In the Malay and Siamese states the Chinaman is said to have shown himself the pioneer prospector par excellence. He has done for these states what the old alluvial gold diggers did for Australia and California—opened up the country, shown its vast possibilities for the investment of capital and the employment of a large population, and, incidentally, in many cases, has made a large fortune for himself. He has not earned the hostility of the European or native population as he has done in Australia and Canada. There a Chinaman saves everything he earns and imports all his food from China, and when he has made money retires and invests it in his own country. In the Malay and Siamese states he acts quite differently, and spends his money freely, taking an interest in the country, and being generous in support of public institutions.

Detecting Carbon Monoxide.

The use of birds or mice in detecting the presence of carbon monoxide in collieries is declared by Mr. George A. Burrell, of the United States Bureau of Mines, to be superior to any chemical tests. One-tenth of one per cent. of carbon monoxide in the air induces symptoms of distress in a man at rest in about two hours. A mouse becomes affected in ten minutes. Larger percentages of gas, say 0·6 per cent., prove fatal to mice and birds in two or three minutes; whereas a human being is apparently unaffected after breathing the mixture for ten minutes. Canaries, on the other hand, are even more susceptible than mice, and their symptoms are much more pronounced. It may sometimes be the case that a mine atmosphere may be so deficient in oxygen that a lamp flame will be extinguished. But there may be no carbon monoxide present, nor may the absence of the normal percentage of oxygen affect either man or bird. In these cases the lack of any signs of distress on the part of the birds is proof that carbon monoxide is not present. Mr. Burrell urges the more general use of canaries as indicators of poisonous atmospheres. By their use the element of personal error is removed.

Largest Coalfields in the World?

Considerable interest is being displayed in Canada in the reported discovery of coal in Baffin Land, and steps are being taken scientifically to explore the district with a view to forming companies for the development of the coal lands. Coming as it does from Captain Janes, a member of the Government Exploration party under Captain Bernier, which explored the coasts of Baffin Land and Hudson's Bay and the islands in the Arctic circle, the report of the discovery of coal-bearing land is held to be above suspicion. Captain Janes, who has just returned, declares that there are two huge coalfields in Baffin Land, about 100 miles apart. The altitude is high, but he believes that despite climatic conditions the fields will be workable all the year round. In his opinion they will prove to be the largest coalfields in the world, and from his examination of the district the coal is near the surface and easily obtainable. There are no trees for 1,000 miles around, but Captain Janes says that he discovered an immense forest in a state of perfect preservation about 25 feet below the surface. The trees point east and west, and lie "as flat as a wheatfield blown down by a cyclone." The timber is in good shape, and even the cones appear to be as fresh as the day on which they fell from the trees. He admits that he did not have time to thoroughly examine the district, but is convinced that coal is there is great quantities.

Colliers and Culture.

Speaking at Rhos Eisteddfod, Mr. E. T. John, M.P., claimed that the Eisteddfod, like the Welsh nation, succeeded in combining strangely great antiquity with perennial youth, vigour and freshness. He argued that one of the most notable features of the Eisteddfod was its remarkable adaptability to modern needs and to an environment relatively difficult and unpromising. As regarded Wales, the Eisteddfod was alike the source and the proof of the high degree of culture which obtained among the democracy. The love of letters and of song was to Welshmen instinctive. With them this was no modern innovation, but the bent and aptitude of their forefathers. Commenting on the support extended to the Eisteddfod by the mining population, Mr. John stated that this felicitous association of colliers and culture, while constantly in evidence in Wales, was also strikingly illustrated by the enthusiastic support accorded by the miners of Northumberland and Durham to the university extension movement. The colliers of Denbighshire obviously did not find the pursuit of a minimum wage a wholly absorbing preoccupation, but, on the contrary, devoted much time to the practice of music and to the study of the charming literature of their native land. He referred also to the place given to the encouragement of art and to the prominence given to social subjects as evincing the modernity and versatility of the national institution.

Lost in Darkness of Mine.

Mr. Willie Phillips, the son of the manager of the Ocean Collieries, Treharris, has undergone an unpleasant adventure, becoming lost in the mine, which is the deepest in Wales. Mr. Phillips, Junr., who is one of the underground officials, went to work in the morning, but did not return in the afternoon as was usual. Three o'clock arrived, and search parties were organised. A fireman who headed one of the parties after a while discovered a coat and hat that had been worn by Mr. Phillips, who later was found, alive and well, except that he was in a weak state from the suffering he had undergone. The explanation is that his lamp went out, and he was forced to grope along in the inky darkness of the pit. In an interview with a *Western Mail* reporter he said: "I was superintending some work underground with men who were engaged in raising some rails. I left the men in order to go to another part of the colliery to see about some other rails, but had not gone very far when I stumbled, and the lamp I was carrying slipped out of my hand. The light was extinguished, and I was left in perfect darkness. In the place where I was there was not sufficient room for me to stand up, and I had to crawl on my hands and knees for a considerable distance. Knowing the danger I was in, I called and tapped, but, curiously enough, I could hear the men at work, but they were unable to hear me. I was afraid to venture too far owing to the peril of my going into an old working, where there was gas and water. I had had no food since ten o'clock in the morning, and I was so thirsty that I had to quench my thirst with tears. I knew a search party had been organised, for I could hear them shouting for me, but, although I responded to them, they could not hear me, as my voice was carried by the air in another direction. I laid myself down near a block-sheet, and was able to receive fresh air by cutting part of it away. It was here I was discovered, having been in the mine for ten hours without food or drink. The reason I was not found earlier was because of a belief among the members of the search party that the road where I stood was stopped. It was through my father's suggestion that possibly I might be in that road that I was eventually rescued."

The Coal Mines Act, 1911.

The Home Secretary has appointed Mr. W. H. Pickering, His Majesty's Inspector of Mines (Chairman), Mr. Frank Brain, and Mr. Robert Smillie to be a committee to consider the provision of washing and drying accommodation at mines under Section 77 of the Coal Mines Act with reference to the following questions: (1) What should be regarded as sufficient and suitable accommodation and facilities? (2) Are different requirements necessary in respect of different classes and descriptions of mines, and, if so, what? (3) What should be the composition and procedure, power and duties of the Committee of Management of the accommodation and facilities provided?

Miners' Relief in Lancashire.

A special general meeting of the delegates of the Lancashire and Cheshire Miners' Permanent Relief Society was held in Wigan to determine upon the expediency of forming an approved society under the National Insurance Act. Mr. W. Scott Barrett, J.P., C.A., who presided, stated that the board of management of the society had already issued papers to the agencies explaining the provisions of the National Insurance Act, and also dealing with the question whether the Permanent Relief Society should form an approved society for the purpose of dealing with sickness insurance under the Act. When the Act was first introduced it was hoped that its administration would be directed solely by the great friendly societies, such as the Oddfellows, the Foresters, and the Shepherds, which for so long, in some cases for a century, had dealt with the work of sickness insurance. If that course had been definitely followed possibly the Permanent Relief Society would have left the work to those societies. Later, however, the Government invited every kind of institution and society, industrial insurance companies, friendly societies, and trade unions, to make application to become approved societies for administering benefits under the Act. That being the case the board of management were forced into the position that virtually every friendly society in the country had taken up. They felt compelled to enter the field and to take steps to administer the sick benefits of the Act. It was unanimously resolved: "That this society become or form an approved society under the National Insurance Act, 1911, and be called 'The Lancashire and Cheshire Permanent Approved Society.'"

Firemen's Certificates: New Order.

An Order of the Secretary of State has been issued, dated May 2, 1912, prescribing form of certificate of qualification of fireman, examiner, or deputy under section 15 (1) (*b*) of the Coal Mines Act, 1911 (1 & 2 Geo. 5, c. 50). By the Order it is prescribed that the certificates given under those provisions shall be in the following form:—

COAL MINES ACT, 1911.

Certificate of Qualification of Fireman, Examiner, or Deputy under section 15 (1) (*b*).

This is to certify that residing at has been duly examined and has satisfied the examiners

(1) (*a*) That he is able to make accurate tests (so far as practicable with a safety-lamp) for inflammable gas;

(2) (*b*) That he is able to measure the quantity of air in an air-current;

(*c*) That his hearing is such as to enable him to carry out efficiently the duties of fireman, examiner, or deputy.

(Signature of person authorised in that behalf by the approved School, Institution or Authority) .....

Date .....

Name of approved School, Institution or Authority .....

(1) (*a*) is to be struck out in the case of a candidate producing a certificate from the manager of his mine that he is employed in a mine in which inflammable gas is unknown.

(2) (*b*) is to be struck out in the case of a candidate producing a certificate from the manager of his mine that he was employed as a fireman, examiner, or deputy on the 16th December, 1911.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications.

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Will some reader kindly show in detail how the constant ·00038 is arrived at in the formula relating to the "equivalent orifice," as applied to mine ventilation?

Yours, &c.,

NOVA SCOTIA STUDENT.

To the Editor of The Science and Art of Mining.

SIR,—Will some reader kindly show by sketches the following:—

Coal is worked from a depth of 300 yards, by two shafts, one cage in each; it is proposed to start and open out another seam 200 yards down the same shaft. Coal to be wound as soon as possible, and still to work lower seam at same time of coal turning.

Yours, &c.,

CONSTANT READER.

To the Editor of The Science and Art of Mining.

SIR,—I would be very pleased if some reader would answer the following questions (Cardiff, 1st class, 1912):—

1.—A mass of lead ore weighs 7 tons. One portion yields 78 per cent. of lead and 8 ounces of silver per ton; the remainder yields lead 75 per cent. and 7½ ounces of silver per ton. The total yield of silver is 55 ounces. What average percentage of lead does the whole mass contain?

2.—Describe four instruments for detecting inflammable gas in mines, and show how you would use one of them for testing.

Yours, &c.,

GLAMORGAN STUDENT.

To the Editor of The Science and Art of Mining.

SIR,—Will TYKE oblige me with answers to the following questions:—

1.—How many tons of coal of specific gravity 1·3, and 3 feet 3 inches thick, are there in an area of 1,000 acres? 1,000,000 tons of coal have been brought to the surface. How many acres are left?

2.—On a plan drawn to the scale of 2 chains to the inch two pits are 9¾ inches apart. What would they be on a scale of 6 inches to the mile?

Yours, &c.,

WELSH STUDENT.

["TYKE" will deal with the questions submitted by "Nova Scotia Student," "Glamorgan Student," and "Welsh Student" as time and space permits.]

Pumps and Pumping.

To the Editor of The Science and Art of Mining.

SIR,—With reference to JAY BEE's difficulty (No. 20, Vol. 22), in connection with the employment of an air vessel fixed to the suction pipe of a Tangye pump, I offer the following:—

An air chamber is usually fixed to the suction range of a pump, no matter of what type, and the benefits derived therefrom can be easily grasped by a slight knowledge of inertia. This is the property of matter by which it tends to maintain its state, whether that be of rest or motion in a straight line. The result is, that in virtue of this law, a column of water when in motion tends to continue so until acted upon by some other force. Speaking in a practical sense, air is very compressible, whilst water, on the other hand, is incompressible, and in the case of an air vessel the former acts as a spring or cushion against the latter, and takes up a portion of the energy, giving it up again during another part of the stroke. This tends to regulate the flow of water from the suction range, and greatly

reduces the impulsive action, and consequently the shock, of the pump stroke. On the suction stroke of the pump the water rushes in at the suction end, and immediately the rod or plunger finishes the stroke the reaction of the water that just rushed in takes place, but is prevented from doing so on account of the momentum possessed by the air in compression, due to the influence of inertia. The result is that the plunger meets with a full barrel of water, hence avoiding, or in any case reducing, shock and consequent wear and tear to the moving parts.

Hoping the above will be of assistance to JAY BEE.

Yours, &c.,

A. NELSON.

COAL.

[*Reflections of a Clayworker in the "British Clayworker."*]

"Take care of the pence—the pounds will take care of themselves" is an old adage—not always representing the truth. Coal and labour are equivalent to the "pounds" of the clayworker's expenditure; they form two colossal items in the annual accounts. Other totals such as oil, insurance, renewals, rates, &c., though worthy of attention when economies have to be considered, are, after all, only "pence" by comparison. To gain any substantial reduction on the expenses side of the accounts, look into the pounds, viz., coal and labour.

Let us examine the item coal. Coal is needed in the first place to provide the power required to crush and grind the clay. In the majority of factories the boiler and steam engine form the power driving unit; in others, internal combustion engines have displaced the steam engine.

The boiler in the former case is mostly of the horizontal type, which, although more troublesome and expensive to install, besides requiring more space, is more economical in working and less exacting in attention than the vertical boiler.

But whether one-flued or two-flued, and whether horizontal or vertical, here is the monster that devours the bulk of the coal and runs up the "out-of-pockets." Here, therefore, is the chief place to look for a saving in fuel expenses. The clayworker can be extravagant in many ways in his fuel bill. He can buy inferior coal—cheap on paper, but dear in practice. He can waste it when he has got it.

There are many ways of wasting it: for example, too wide gaps between fire-bars; not heating the feed water; allowing scale to accumulate on the internal heating surface, or soot to gather in the flues and block the draught; working the dampers badly, and allowing too much draught; wasting steam through leaky joints and steam pipes; not covering boiler, steam pipes, and engine with some good non-conducting compound, &c., &c.

If the fire-bars have too wide gaps, of course the smallest coal falls through with the ashes, and is unconsumed. The heating of the feed water—a very simple matter—is a large factor in fuel economy. As for the scale, the extravagance of allowing scale to exist at all is such that where it happens it would pay to install a water softener to treat the water before entering the boiler, and thus prevent or minimise the tendency to scale. The cost of the softener would be saved in fuel and in labour and stoppage for cleaning and chipping out in probably a couple of years. The other items named, viz., keeping flues cleared of soot, keeping dampers properly adjusted, and keeping all joints steam-tight, depend entirely on the stokers. Look after them.

In the case suggested above the exhaust steam is usually made use of for heating drying sheds. The highest authorities on steam engine practice maintain that the compound engine utilising the steam from the high pressure cylinder to drive a low pressure cylinder is the essence of fuel economy. Clayworkers generally, however, consider the exhaust can most effectually be used for heating purposes. Here is a chance for the theoretician to step in and say whether the average clayworker is right or wrong. Would he get more value for his fuel money by adopting compound engines and having reduced heating capacity?

In the case of internal combustion engines being used, to the exclusion of boiler and steam engine, the question of fuel is of smaller importance as regards the power. Power is generated with extreme economy, but there is no exhaust of any value, and so the fuel question again crops up for heating—either by live steam or coal heated flues, both incomparably dearer than exhaust steam.

As to live steam the foregoing remarks apply in every respect. And as to heated flue drying sheds the remarks as to fire-bars and dampers are quite in order. It will pay the clayworker to see the length of the shed flues is correct. If too long it means heavy firing to drive the heat to the far end—and consequent thickening of the shed floor at the furnace end. If too short, the fuel may be wasted by the products of combustion reaching the chimney before its heating value is all extracted. There is a happy medium.

There remains the question of coal used in burning. There are far too many varieties of kilns in use to be enumerated here. All, however, are coal eaters, and the student of fuel economy has plenty of scope for his hobby. Whether continuous or intermittent, kilns should be kept in order, and all flues, dampers, wickets, brickwork, &c., kept as air-tight as practicable. It does not pay to draw cold air except under control and when required. Here again, as in the consideration of boiler fuel, it is not necessarily an economy to buy "cheap" fuel. Get the quality right, then buy well, and, lastly, keep to the quality that suits, and do not change it. Nothing bothers the kiln burner more than changes of fuel. The kiln burner has the question of profit or loss in his keeping more than the boiler stoker. A badly burned kiln not only means wasted coal; it may mean the loss of the bulk of the goods in the kiln, either by under or over burning. Ponder well, then, before you palm off inferior coal on your kiln work. Soft goods, swelled goods, blackened or discoloured goods, all mean waste of fuel, in addition to reducing the receipts per kiln. So the fuel question may cut both ways, both by increasing the expenses and diminishing the receipts.

Continuous kilns are vastly more economical in fuel demand than intermittent kilns. There is—or should be—no waste heat going up the chimney. The regenerative principle is cleverly applied, and after the link is once started (and if properly handled by burners) every particle of coal has its utmost value extracted. Although the cycle of combustion is well known, there yet may be clayworkers to whom a description will be new. When once alight, the coal air required for combustion is drawn through the burned goods, thus cooling them and simultaneously heating up the feed air, which thus arrives at the point of fuel combustion at an exceedingly high temperature. There mingling with the fuel gases the joint product undergoes combustion. In the old clamp kilns, and in most existing intermittent kilns, the products of fuel combustion then go to waste, either direct to the atmosphere or *via* the factory or kiln chimney. Not so in the continuous kiln. The "waste heat" here passes through the newly set green bricks, heating them up ready for the fire, which quickly follows, and by the time the chimney is reached the waste gases have given up all their heat in the good cause. In some districts—Peterborough, for example—owing to the natural gas in the clay, it is possible to have a chamber of bricks in an incandescent state before a scoopful of fuel has been fed in the chamber.

R.

A PIT SINKING RECORD.

At Barony No. 1 Pit, Auchinleck, Ayrshire, belonging to Messrs. William Baird and Co. (Limited), Mr. John Toole, the contractor sinker, has created what is believed to be a record for pit sinking in Scotland. A depth of 75 fathoms was cut in a period of 16 weeks, being an average cutting of nine fathoms and two feet per fortnight. The pit is 21 feet by 11 feet inside the wood. In addition to the sinking the whole distance was wooded, three large permanent lodgments were cleaned out, and the pumps attended to, and the pistons of an Evans hanging sinking pump renewed twice. The water at the pit bottom is taken out every Sunday night by means of a large water barrel with a holding capacity of 3 tons of water. This water is brought to the surface, which is 341 fathoms from the pit bottom.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

No. 9.—Coal Dust.

Realising from a consideration of historical facts and the results of experimental research that coal dust in a mine is, under certain circumstances, exceedingly dangerous, it becomes necessary for all underground officials and workmen to understand in detail the conditions that give rise to danger and the practical precautions that are necessary to avoid such danger.

Before a coal dust explosion can occur two main conditions must be satisfied :—

1.—The dust must be dry, finely divided, and some must be suspended in the air at the time of its ignition.

2.—There must be an igniting medium of reasonably high temperature projected into the dust.

Experience has shown that the sources of ignition are practically limited to two types, which may act singly or jointly. These are :—

1.—Flame produced during shot-firing, either from blown-out shots, lack of skill in placing the holes, lack of judgment in estimating the charge, or by deliberate misuse.

2.—Flame from small explosions of fire-damp which, without the presence of coal dust, would have been local in their effects.

Both these igniting media act with explosive energy, part of which assumes the form of mechanical force, the remainder being expended in the development of a high temperature. If fine, dry coal dust is in the vicinity of their action, the mechanical force may raise the dust from repose and cause much of it to be suspended in the air, thereby creating an explosive atmosphere which may be ignited at the instant of its creation by the existing high temperature.

Once ignited the explosive force developed will raise further dust which in turn will explode, these operations being repeated until the flame and force have travelled throughout the dusty region.

It must be remembered, however, that ease of ignition depends largely on the fineness of division of the coal dust particles in suspension at the instant of the projection of the flame into the dust cloud, or of the dust into the flame, and that it is not an impossibility for ignition to be produced by any open flame.

To procure safety from coal dust explosions two main lines of action may be attempted :—

1.—The presence of dust *in a dangerous condition* may be prevented as far as is practicable.

2.—The chances of ignition may be considerably reduced by the abolition of shot-firing and the adoption of good ventilation to avoid the formation of local fire-damp mixtures.

Where circumstances compel the use of explosives, they must be used under stringent regulations, by responsible persons skilled in their use who fully understand the possible effects of a mishap, or of an error of judgment.

In circumstances where local accumulations of fire-damp cannot always be avoided special precautions must be taken to avoid the ignition of such by open lights, defective safety lamps, open sparking from electric cables or machines, improper shot-firing, &c., fully realising that an explosion of the gas is only a minor danger compared with that due to the presence of dust.

The presence of dangerous dust may be avoided as follows :—

1.—By preventing its formation as far as the practical circumstances will permit.

2.—By preventing its accumulation in circumstances where its formation cannot be avoided.

3.—By rendering the dust harmless where its accumulation is considered to be inevitable.

When dealing with the security of a mine from coal dust explosions it should be remembered that there is no royal road to safety. This can be procured only by constant vigilance. Slackness on the part of a single official may render ineffective the efforts of all the others, and may be the starting point of a disaster.

As a rule each particular pit has its own dust problem, which can be solved only by the application of intelligence to the existing physical and economic circumstances.

So far as the under-official is concerned his duty in this matter will largely be to carry out preventive schemes formulated by superior officials. He will still have considerable opportunity to exercise his judgment in working out the details of any particular scheme, and reference may now be made to details that are important.

The Formation of Coal Dust.—The principal sources of coal dust were enumerated by the Royal Commission on Mines in their second report, as follows :—

1.—From the screens.

2.—Falling through open sides or crevices in badly constructed tubs or trams.

3.—Falling off loaded tubs or trams filled above the top.

4.—Blown from the top of full tubs or trams travelling against the air-current, especially in the case of fast haulage.

5.—Blown from full tubs going up the shaft against the descending air-current.

6.—Thrown up by the traffic of men and horses.

7.—Continuous grinding up of the coal seams in the roof and sides of roads.

8.—Small coal left in tubs or trams after tippling.

9.—Carried from the face to the return air-ways by the ventilating current.

10.—Produced by the use of high explosives.

Numerous other sources might be added to the above list, including the use of mechanical coal cutters, cutting in the coal, the use of mechanical face conveyors, the use of over-tub haulage, the excessive bumping of tubs on badly laid roadways or at junctions with improper gradients.

Dust from screens placed near the downcast shaft comes under the influence of the fan. It is carried down the pit in large quantities by the moving air-current and deposited in convenient crevices and on projecting ledges in and about the shaft sidings and roadways leading to the shaft. Through time all surfaces on which this dust can repose become coated with it for a considerable distance from the shaft.

This screen dust is usually very pure and is exceedingly fine. In many cases more than 98 per cent of it will pass *through* a 240 mesh. Owing to these two facts, the presence of screen dust in a mine must be recognised as a danger and dealt with accordingly.

Remedial measures resolve themselves in the removal of the screening plant out of the influence of the ventilating fan or of intercepting the dust before it comes under such influence, with the object of preventing the dust getting into the air-current.

Defective, badly designed, or improperly loaded tubs or trams are probably the most widely extended sources of coal dust found in mines. Every piece of coal falling from such tubs on to the roadway ultimately disintegrates under the influence of air and moisture, or is crushed to a powder by the passing traffic. Every time a cloud of dust is raised by the passage of men, horses, or a train of tubs, the finer particles are caught up by the air-current, carried in suspension for a time, and then deposited on the roof, the tops of bars, ledges on the sides, &c., at the first convenient opportunity. Thus every passing tub may be an agent in manufacture of dangerous dust.

To prevent this manufacture of dust all tubs should be made *dust tight* in box form, without flaps or doors, and should be kept in an effective state of repair.

The main roadways should be well laid with regular and properly jointed rails in order to prevent unnecessary jolting of tubs and their possible derailment or wreckage. This latter is a prolific source of dust, as it is practically an impossibility to completely clean up a wreck unless the floor has been properly paved with bricks.

At all junctions and places at which tubs are habitually stopped and started a well-paved floor is desirable in order to facilitate cleaning up, and the gradients should be laid so that unnecessary bumping and jerking of tubs may be avoided. As a rule it is at these places that dust is formed in largest quantities.

Care should be taken that tubs are not loaded above the sides of the box when small and medium sized coal is being filled.

Where mechanical haulage is required the slow moving endless rope system should be used, and preferably, the under-tub

type. With the over-tub type coal is apt to be knocked from the top of the tub by the rope, thereby increasing the quantity of dust.

The production of dust by the grinding of pillars and at the working face cannot well be avoided, and it is inevitably involved in the use of coal cutting machinery and face conveyors. The quantity may be kept at a minimum, however, by leaving large pillars, where such are considered necessary, by maintaining the working face as straight and regular as possible, and by holing in the underclay rather than in the coal.

While this face dust is, as a rule, more volatile than road dust, it is usually coarser in texture, and in ordinary air is relatively safer. If, however, a small amount of gas is present in the air-current passing along the face, the comparative safety due to the coarser texture of the dust is at once destroyed.

The Removal of Dust.—In order to prevent the accumulation of large quantities of dust the roadways should be periodically cleaned, the dust being swept up, filled into tubs, and sent out of the pit. In order to facilitate this work the sides of the roads should be made as smooth as possible, and the crevices on the tops of bars and girders filled up. In settled roadways this may be effected by plastering the sides with a cheap cement, and blocking up the space between girders by wood blocks, afterwards coating with several layers of limewash. This improves the lighting of the mine, renders dust more visible, and provides a smooth and even surface on which dust cannot accumulate.

When cleaning a roadway the finest particles of coal dust cannot be filled up. Immediately they are disturbed they float off in the air-current and settle down again at some point further along the roadway. Thus dry sweeping may result in the finest dust being distributed over a greater length of roadway.

To get over this difficulty, in circumstances which permit water to be used, the dust may be damped and knocked off the roof and sides previous to sweeping; or wet brattice sheets may be hung across the roadway to intercept the floating dust and prevent it being carried by the air beyond the section being cleaned. By removing dust from the roadways considerable benefit is undoubtedly derived, but there is little hope that complete safety from explosion can be secured by this alone.

The Treatment of Coal Dust.—In order to render coal dust harmless two main methods are adopted, the application of which depends on the circumstances of each case.

In one, the object is to prevent dust rising into the air and so forming an explosive mixture.

In the other, the object is to destroy the combustible properties of the dust by the addition of inert matter, such as fine shale dust, so that when raised in a cloud the mixture of dust and air is not explosive.

The treatment to be adopted on any particular roadway depends upon the nature of strata in which it is driven. Many shales and clays associated with coal seams, when moistened with water begin to expand, lose their strength and structure, and finally break up into innumerable pieces.

In some kinds of strata, particularly mudstones, limy shales and underclays, the disintegration acts rapidly, many cases being known of roadways that have collapsed soon after the first contact with water.

Where watering can be carried out continuously on an ample scale it is undoubtedly an effective remedy, provided the water is applied to the roof and sides and *not to the floor alone.* Watering by means of a water tub or barrel cannot be considered an effective system.

Two main systems of watering are used. In both, water pipes are laid along the main roadways, being supported from the roof bars or at the side as found necessary.

In one system a series of fine spray jets are fixed on the main pipe at suitable intervals best determined by experience. A fine spray of water is constantly emitted under pressure from the jet, which has the effect of keeping the dust constantly damp.

In the other system stand pipes fitted with valves are fixed to the water mains at intervals of 40 to 50 yards apart. A hose pipe about 20 yards long is fitted to these as required. A workman directs the end of this hose to all parts of the roof and sides within the limits of its range, and causes a fine spray of water to impinge upon the dust, thoroughly damping it, and, if skilfully done, knocking all dust from the roof and sides.

All systems of watering when once started should be continuously maintained. If a watered roadway is allowed to become dry the quantity of dust will be found to be increased, owing to the disintegration produced by the intermittent wetting, This may also lead to the break up of the roof and sides, and increase the possibility of accident.

To a small extent various chemical substances have been applied as means of damping coal dust; calcium chloride may be taken as being typical. This is applied either in solution or as a powder to the coal dust. It has the property of readily absorbing moisture from the air-current, and, being mixed with the dust, this extracted moisture helps to cake the dust and keep it from rising into the air-current.

In circumstances in which water cannot be used it is necessary to apply the second method referred to above.

That treatment with shale dust renders more difficult the ignition of a mixture of coal dust and air, and tends to stop the propagation of an explosion, would appear to be proved by the experiments at Altofts and at other stations.

Reference has previously been made to the similarity between a mixture of gas and air, and a mixture of fine coal dust and air. It is probable that the mixing of fine shale dust with the coal dust has a similar effect on its combustion to that produced by the addition of a large quantity of black-damp to an explosive fire-damp mixture.

The shale dust used requires to be ground to the fineness of the coal dust. This is done in a grinding mill.

The dust having been sent down the pit is taken in tubs to the appointed place and, in handfuls, is thrown against the sides and roof, and on the top of the timbers. This displaces the coal dust and the crevices become filled with shale dust, giving a white appearance to the sides and roof. As soon as this white appearance is lost, owing to the deposit of coal dust, another dressing of shale dust is given.

The number of dressings given varies from one to four according to the rate of deposition of the coal dust.

If this treatment is faithfully carried out in an intelligent manner it is highly probable that the risk of a coal dust explosion will be considerably diminished, though, unfortunately, not entirely eliminated.

The question of coal dust has been discussed with some detail owing to the prejudice which, the writer knows from experience, exists in the minds of so many under-officials against what is still called the coal dust "theory."

It is very desirable that this prejudice should be removed in the interests of safety, and particularly as it will probably fall to the lot of the fireman, examiner, or deputy to carry out those parts of section 62 of the Coal Mines Act, 1911, that apply to underground workings.

Section 62 reads as follows:—

62.—In every mine unless the floor, roof, and sides of the roads are naturally wet throughout—

(1) arrangements shall be made to prevent as far as practicable coal dust from the screens entering the downcast shaft; and in the case of a mine newly opened after the passing of this Act, no plant for the screening or sorting of coal shall be situated within a distance of eighty yards from any downcast shaft unless a written exemption is given by the Inspector of the division;

(2) the tubs shall be so constructed and maintained as to prevent, as far as practicable, coal dust escaping through the sides, ends, or floor of the tubs, but any tub which was in use in any mine at the date of the passing of this Act may, notwithstanding that it is not so constructed, continue to be used in that mine for a period of five years from the said date;

(3) the floor, roof, and sides of the roads shall be systematically cleared so as to prevent as far as practicable coal dust accumulating;

(4) such systematic steps, either by way of watering or otherwise, as may be laid down by the regulations of the mine shall be taken to prevent explosions of coal dust occurring or being carried along the roads;

(5) the roads shall be examined daily and a report (to be recorded in a book kept at the mine for the purpose) made on their condition as to coal dust and on the steps taken to mitigate danger arising therefrom.

NOTE.—There appears to be some confusion regarding the requirements of Section 15 of the Coal Mines Act, 1911.

This requires that after January 1st, 1913, EVERY PERSON acting as a fireman, examiner, or deputy in a mine to which the Act applies must be certificated.

Persons at present in the position of a fireman, examiner, or deputy are exempted from certain subjects of examination.

In the full examination each candidate not being at present a fireman, examiner, or deputy must show—

(1) that he is able to make accurate tests, so far as practical with a safety lamp, for inflammable gas;

(2) that he can measure the quantity of air in an air-current;

(3) that his hearing is such as to enable him to carry out his duties efficiently.

ALL present firemen, examiners, or deputies will be examined in gas testing, except *those employed in mines in which gas is unknown.*

ALL present firemen, examiners, or deputies are *exempted* from examination in air measurements.

ALL candidates, whether at present in positions or not, will be required to pass the hearing test.

COLLIERY ENGINEERING.

By CLANSMAN.

Graphic Arithmetic (continued).

Division.—To divide any line by another line, that is, to find the quotient of two lines, draw two indefinite lines inclined to each other at any convenient angle (90° is perhaps simplest). On one of these lines set off from the intersecting point or origin a length equal to the dividend. On the other line set off from the origin a length equal to the unit, and also from the origin, and on the same line a length equal to the divisor. Join the end of the divisor to the end of the dividend by a line, and through the end of the unit length draw a line parallel to this. It will cut off a length on the other line equal to the quotient.

Let A be a line 9 units long, B a line 6 units long, and C the unit. (*Figure 11*). Draw the lines OX and OY at any convenient angle. On OX mark off a length $OA = A$, and on OY mark off a length $OB = B$. Also make $OC = C$, the unit. Join BA, and draw a line through C parallel to BA, cutting OX at L. Then OL is the quotient $\frac{A}{B} = \frac{9}{6} = 1\frac{1}{2}$.

Proportion.—In simple proportion we consider four quantities which are proportional, and if the quantities be A, B, C and D we write them as $A : B :: C : D$. If we are given the value of any three we can find the fourth. A and D are called the extremes. B and C the means. $A : B$ and $C : D$ are called ratios, and may be written $\frac{A}{B}$ and $\frac{C}{D}$.

To find the fourth proportional draw two lines at any convenient angle to each other. On one set out a distance equal to the first extreme, and on the other a distance equal to the first mean, and join their ends. Set off alongside the first extreme the second mean, and from its end draw a line parallel to the line joining the ends of the first extreme and the first mean. It cuts the line on which the second mean is set off into a length equal to the fourth proportional.

Given (*Figure 12*) the lines A, B and C to find the fourth proportional.

Draw two lines, OX and OY, at any convenient angle, and set off from O on OY a length equal to A, the first extreme.

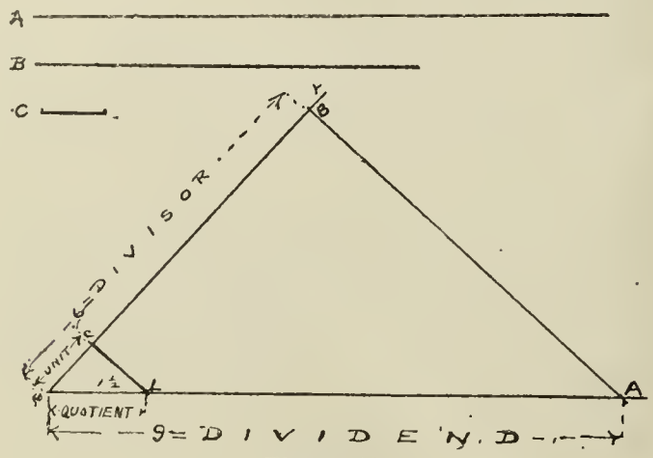

Figure 11.

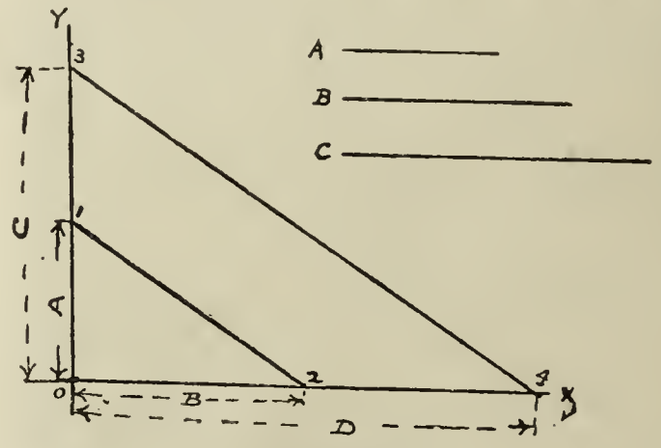

Figure 12.

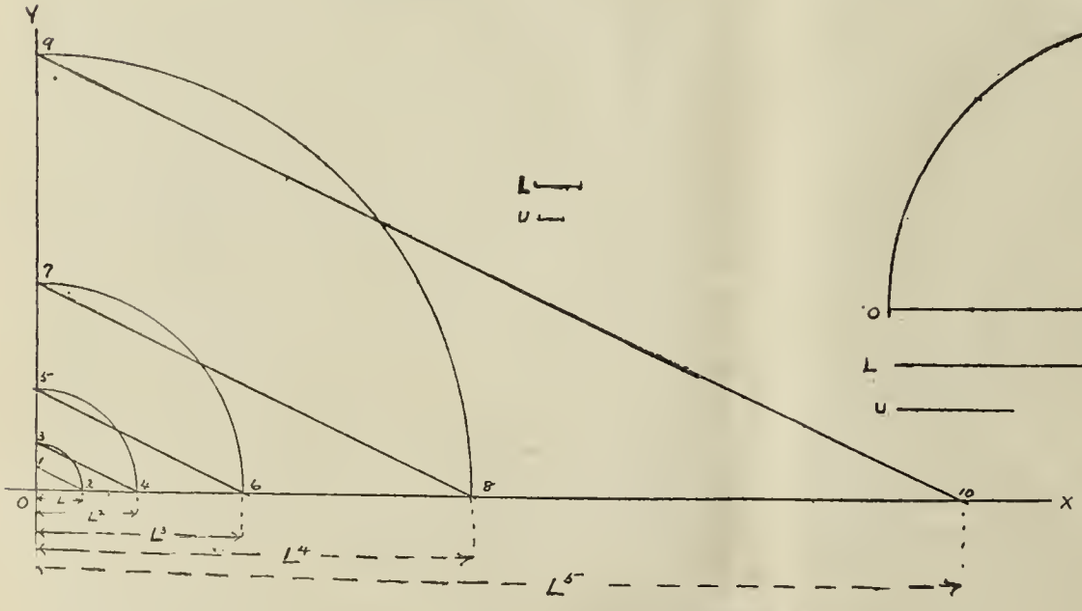

Figure 13.

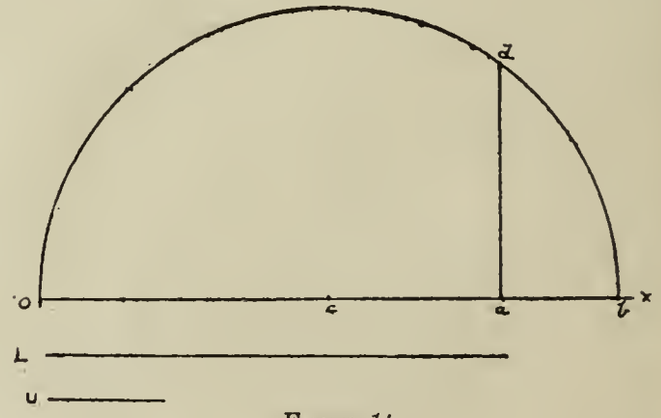

Figure 14.

On *OX* make *O2* equal to *B*, and join the points *1* and *2*. On *OY* make *O3* equal to *C*, and draw through *3* a line parallel to *1, 2*, cutting *OX* at the point *4*. Then *O4* is the fourth proportional.

Involution.—To find the square or any higher power of any line draw two lines at right angles. On one set off the length of the unit and on the other the length of the line to be squared or raised to some higher power. Join the ends of these lines. Now set off along the unit line the length of the line given, and from the end of it draw a line parallel to the line joining the ends of the unit and the line to be squared. This line cuts the other line into a length equal to the square of the length given. Now, if this line so found be set off along the unit line, and a line drawn through the end of it parallel to the line joining the ends of the unit line and the given line, this will cut the other line into a length equal to the cube of the given line, and so on.

Let *L* (*Figure 13*) be a line which we are required to square, and also raise to the third, fourth, and fifth powers. Draw *OX* and *OY* at right angles. On *OY* make *O1* equal to the unit, and on *OX* make *O2* equal to *L*. With *O* as centre, and radius *O2*, cut *OY* at *3*. Through the point marked *3* draw a line parallel to 1, 2, cutting *OX* at *4*. Then, $O4 = L^2$.

With *O* as centre and L^2 as radius cut *OY* at *5*. Through this point draw a parallel as before, and $O6 = L^3$.

With *O* as centre and *L3* as radius cut *OY* at *7*. Draw a parallel as already indicated, cutting *OX* at *8*. Then, $O8 = L^4$.

Similarly, take L^4 as radius, find point *9*, draw parallel, and cut line *OX* at the point marked *10*. Then, $O10 = L^5$.

Evolution.—To find the square root of a line draw a line, making it equal in length to the line given plus the unit to which it is drawn. Bisect this line, and on it describe a semi-circle. A perpendicular drawn from the point where the unit is joined to the given line till it cuts the semi-circle will be equal to the square root of the given line.

Let the line *L* (*Figure 14*) be a line given whose square root is required, and line *U* be the unit.

Draw a line *OX*, and from *O* make $Oa = L$; from *a* make $ab = U$. Bisect the line *Ob*, *i.e.*, divide it into two equal parts, *Oc* and *cb*. At *c* describe a semi-circle, with *cb* as radius.

Through *a* draw a perpendicular cutting the semi-circle at *d*, then, $ad = \sqrt{L}$.

NOTES FROM WALES.

By BRYCHAN.

Haulage—(continued).

Curves.—Where a curve on a main and tail engine plane has to be negotiated the tail rope should be carried round one or more large pulleys in preference to a large number of small rollers or sheaves. A rope requires not only a fairly large radius to work round, but bearing surface as well. If this bearing surface is not provided the life of the rope is short.

Assume a right angle bend to be passed, and that a pulley 5 feet diameter is used to carry the rope round. The bearing surface for the rope in this case will be $\frac{5\pi}{4} = 1\frac{1}{4}\pi$, practically 4 feet. If a dozen small sheaves were substituted, each say 6 inches or 8 inches diameter, since the rope is only in contact with each sheave for a very short distance, the percentage of bearing surface to the total bent portion of rope is very small, probably not exceeding 20 per cent. On the other hand, with the 5 feet pulley the bearing surface is 100 per cent. of the bent part of the rope.

On the matter of taking ropes round curves, it must not be forgotten that there is very great resistance to motion at this point, and the only thing to do is to make the radius as easy and the pulleys as large as may be. The friction due to the 4-inch journal of a 5 feet pulley is much less than the friction due to about twelve sheave or roller spindles, each about 1 inch or $1\frac{1}{8}$ inch diameter, the ratio being about 1 : 3. Besides, the attendant has to attend to the oiling of only one, or at most two large pulleys, instead of so great a number of small ones, which are apt to be more or less neglected. *Figures 155* and *156* illustrate a suitable method of negotiating a sharp curve on a main and tail engine plane.

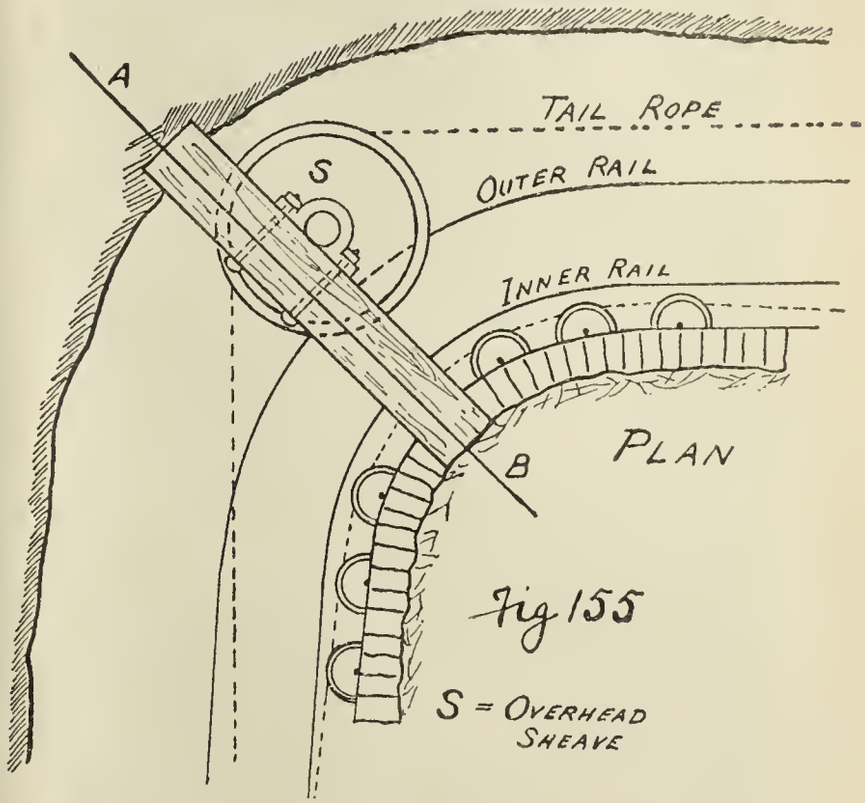

Fig 155

Pulleys, sheaves, rollers, &c., should be oiled at least once a day, or, better still, twice, a sharp look out being kept on the amount of wear of the rope on the tread. A sheave or pulley whose tread has been worn through by the rope becomes a source of danger to the rope if not removed. Even if there is a shortage of new material to replace the worn article, it is better to leave the rope without support than to let the old sheave remain. The same remark applies to rollers fixed upon the floor in the centre of the roadways. All these castings should be of crucible steel or manganese steel, as these give the greatest strength and wearing capacity, with the least weight.

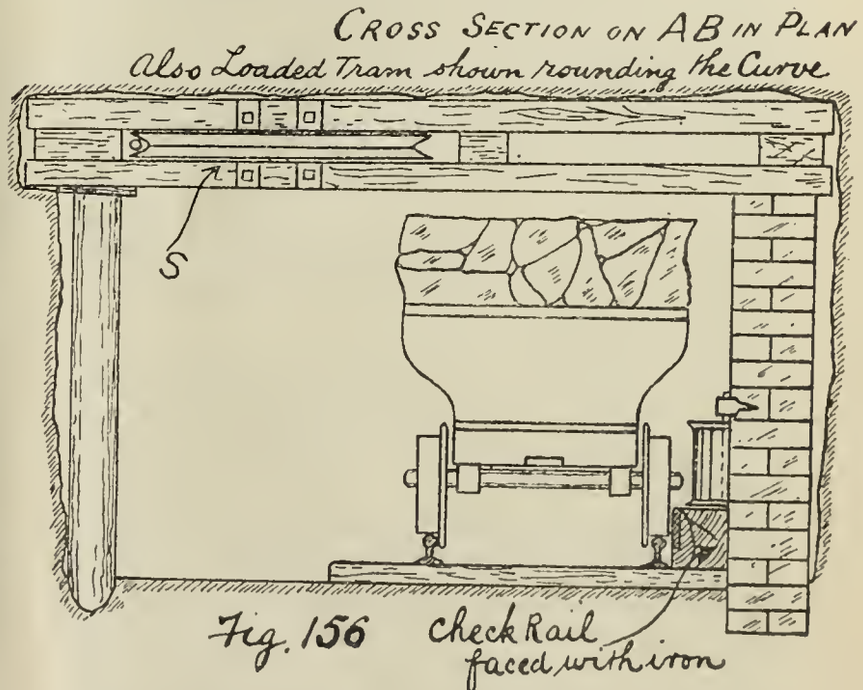

Fig. 156

METHODS FOR THE PRESERVATION OF MINE TIMBERS.

By G. B. McDONALD.*

The subjects of decay and seasoning of timber are more or less closely associated with the matter of preservative treatment. Decay in wood is an organic process caused by low forms of plant life, either bacteria or fungi. The bacteria are microscopic in size, but the fungi become quite conspicuous when the fruiting bodies appear on the surface of the wood. The fungi consists of small threads which penetrate the wood structure, and these are the real cause of decay rather than the fruiting bodies commonly known as punks or brackets. Under proper conditions the spores produced by the fungi gain access to the wood structure and decay soon begins. The spores of the rot-producing fungi may gain access to the timber either before or after the timber has been felled, but it is generally the case with mine timbers that the disease is contracted after the timber has been placed in the mine, due to its close proximity to other decaying timbers. A rough wood furnishes excellent places for the lodgment of spores and also good conditions for holding moisture, thus hastening the process of decay. Although timbers may have been sufficiently treated externally with some good preservative, yet the spores often gain entrance to the interior of the stick through season checks or cracks which are not thoroughly protected by the preservative fluid. It is frequently the case that a fungus is growing in the timber before the tree is felled. If the fungus is subsisting on live wood and is not able to survive on dead tissue, the felling of the timber causes the death of the fungus, and avoids further decay from that source. If the fungus is developing in the heart wood of the tree, which is practically dead tissue, the rot may continue to develop after the tree has been cut down and worked up into mine timbers.

Wood is composed of small cells which are made of cellulose; around these cells is a substance known as lignin. Some species of fungi attack only the cellulose of the wood, others only the lignin around the cells, and still others disintegrate both lignin and cellulose, causing a complete breaking down of the wood structure. After the wood is first attacked by a fungus discolouration takes place, and later the wood fibres are changed to such an extent as to make the wood soft, brittle, and practically worthless for any purpose. Any fungus must have for its proper development a supply of moisture, heat, air, and food. Without any one of these the fungi cannot develop. In places where the timbers are constantly dry there is no danger of rot-producing fungi doing damage. The conditions which hasten the rotting of timber are those where the wood is constantly subjected to alternate wetting and drying. A good circulation of air is also an important factor in preserving timber in a mine, in that it tends to reduce the amount of moisture present. Shafts where ventilation is poor, where there is an abundance of moisture and heat, are the most favourable for the development of fungus diseases. Although the loss of mine timbers can never be wholly prevented, yet the life of the timbers can be very materially increased through proper methods of seasoning and preservative treatment.

For all classes of round timber, either posts, piles, or mine props, it is thoroughly understood that the removal of the bark prevents decay to a certain extent. This is due to the fact that while the bark is on, the wood adjoining the inner bark is kept constantly moist and the conditions are ideal for the development of fungus. The peeling is effective inasmuch as it hastens the seasoning process. The cost of peeling is an item which must necessarily be considered; however, we are told by the Forest Service that it costs only from 20 to 50 cents. per ton to peel mine timbers. It is no doubt true that many times this amount is saved by the increased length of life of the timbers. The simplest means of materially increasing the life of wood is by proper seasoning. It is well known that the amount of moisture in any piece of green timber depends upon the part of the tree from which the timber has been cut. The outer zone of a tree, or the sap wood, contains a much greater amount of moisture than the heart wood. On this account, and for the reason that the outer zone is more exposed to fungus spores, the sap wood is more subject to decay than the heart wood. On the other hand, the sap wood portion of a tree will season more rapidly than the heart wood portion. By piling the timber in such a manner as to permit a free circulation of air, the seasoning process can be accomplished quite rapidly. However, the time required for the seasoning depends to a large extent on the climate. By kiln drying the moisture content of the timbers can be reduced to a smaller percentage than by the mere process of seasoning; however, this will add a considerable item of expense. It is well known that by reducing the moisture content the strength of the wood is materially increased, provided that an excessive amount of moisture is not given off so that the wood structure is affected. A piece of timber well saturated with moisture is generally considered about one-half as strong as a properly seasoned stick.

Seasoning will prevent the work of rot-producing fungi so long as the timber remains comparatively dry. When the timber is to remain in a moist situation, another method may be employed, that of poisoning the food supply of the fungi. This is brought about by injecting a poisonous fluid into the structure of the wood or by merely applying a coating of some antiseptic to the surface of the timber. A great variety of preservatives have been tried out in the United States and also in other countries; however, there are only four which need to receive serious attention. These are creosote, zinc chloride, corrosive sublimate, and copper sulphate. At the present time in the United States the last two have been almost discontinued. There are a large number of patent preservatives for sale, all of which have as a basis either zinc chloride or creosote. Creosote as used for the preservation of timber is a by-product of coke-oven plants. Unlike zinc chloride, creosote is a very complex substance, being composed of a great number of compounds. Both zinc chloride and creosote are exceptionally good preservatives, yet creosote has the advantage in that it is not soluble in water; this fact making it superior for preservation of mine timbers, especially those subjected to moist situations. When once injected into the structure of the wood, creosote will not wash out. Zinc chloride is cheaper, but timbers preserved with this fluid are only serviceable in comparatively dry situations.

The methods of preservation of mine timbers may be covered under three heads: First, surface treatment; second, open tank treatment; and third, high pressure treatment. The surface method has been used to some extent in the treatment of mine timbers. This method in its simplest form consists in applying a thin coating, preferably of hot preservative, to the timber by means of a paint brush. The objection to the method consists primarily in the fact that it is difficult to get the preservative well into the season checks, knot holes, &c. The preservative in this case only penetrates a very thin zone; however, as long as this zone of preservative remains unbroken there is little danger of decay. In this method it is especially important that the timber be thoroughly air dried before the preservative is applied, otherwise the evaporation of the moisture from the interior of the stick will cause checks and expose some of the unprotected wood to the fungi. This method is often used where only a small amount of timber is to be treated, an amount which would not justify the installation of the apparatus required for the use of other methods. It is often the case that the brush method of treatment is a more expensive means of preserving the timbers than by dipping them in a tank. If the proper apparatus is available, it is a much simpler and quicker method to immerse the timber for a short time in the preservative. The dipping process is not only more economical of labour, but by its use season checks, cracks, &c., are covered more satisfactorily than if the brush is used. The preservative will penetrate the surface of the wood better if it is warmed before immersing the timber. In some cases, the timber may be allowed to remain in the fluid for a few minutes before being removed; however, this method is entirely different from the one to be described under open tank treatment.

In the open tank treatment the penetration is secured by an entirely different process. This method compares more nearly with the high-pressure method than to the dipping or surface treatments just described. After the wood is thoroughly seasoned and a greater part of the moisture in the cells and cellular spaces is replaced by air, the timber is immersed in a

* From the *Iowa Engineer*.

hot bath of creosote or zinc chloride, as the case may be. The hot bath is continued from five to six hours, depending upon the kind and condition of the timber. In the hot bath the air and moisture in the wood expand and a portion of them pass off. At the conclusion of the hot bath, as quickly as possible a change is made to a preservative having a low temperature. This causes a contraction of the air and moisture still remaining in the wood, thus creating a partial vacuum which draws the preservative into the wood. In this method, through atmospheric pressure, is accomplished the same results as with artificial pressure under the "high pressure process." Green timber is very unsatisfactory to treat by this method, since it requires a much longer time to make the treatment, and there is an unnecessary loss of preservative through volatilisation. The penetration of the wood may be secured by any one of the following schemes : First, after the timber has remained in the hot preservative for some time, the heat may be withdrawn and the preservative allowed to cool without changing the timbers from the tank or without changing the preservative ; second, the timbers may be transferred from the hot tank to another containing a cool preservative ; third, after the heating process, the preservative may be drawn off and replaced by a cool solution without removing the timbers.

For a small operation a convenient outfit might consist of an old iron boiler 10 feet in length, placed vertically in the ground, and set to a depth of about 5 feet. For a small job it would not be necessary to have the tank fitted up with steam coils for heating the preservative. It would only be necessary to construct a fire-place beneath the tank and heat the preservative by direct heat. This outfit is very commonly used in the preservative treatment of fence posts. It is desirable to make the treatment as short as possible, not losing sight of the fact, however, that a certain amount of time is required to secure the object desired by this method, namely, a good penetration. The process is in reality a pressure process and differs radically from the mere dipping of the timber. The time necessary to secure the desired penetration will vary with the species and the moisture content of the timber, and also with other factors. Many species of timber have a heart wood that is difficult to penetrate. With these it is generally useless to continue the treatment after the sap wood or outer portion of the stick is thoroughly penetrated. The absorbing process takes place generally during the cooling of the liquid. It is not desirable in treating to allow the temperature of the hot fluid to go above 215 to 230°F., since the strength of the timber may be decreased. With most species of wood, especially those having a wide sap wood, a complete treatment of this outer portion of the wood will afford a good protection for the entire stick. The open-tank method is not adapted to species which resist the penetration of the preservative fluid.

Under the high-pressure method, the two processes most commonly used are the "Bethel" and "Burnettising." These processes are the same, except that in the former creosote is the preservative used, and in the case of the latter zinc chloride. The method of injecting the preservative is practically the same in both cases. The timber to be treated is placed on iron trucks which are rolled into large horizontal iron cylinders, some of which are 8 or 9 feet in diameter and 150 feet in length. These cylinders are constructed so as to withstand high pressure, and the doors fitted up so that they can be tightly sealed. After the cars of timber are placed in the cylinders, steam is admitted at a pressure of about 20lb. to the square inch, and this pressure is maintained for several hours. The steam is then blown off, and vacuum pumps are started which remove a large portion of the air and moisture from the wood structure. This process is continued several hours also, after which the preservative is run into the cylinder at a temperature of 160°, the pressure pumps are started, and a pressure maintained until a sufficient quantity of the preservative is forced into the wood. The preservative is then drawn off, and in a few minutes the timber is ready to be withdrawn.

The "boiling" process is very frequently used for treating green timber. The equipment is practically the same as for the above processes except that the hot bath may be continued from a few hours to a couple of days, depending upon the size and condition of the timbers being treated. During this prolonged hot bath much of the sap and moisture of the wood is driven off by being forced out of the wood through expansion. After the hot oil is drawn back into the receiving tank, cooler oil is pumped in, and put under a pressure of 100 to 125lb. per square inch, thus causing a very good penetration, inasmuch as the method takes advantage of high pressure along with a certain amount of penetration which is obtained, due to the treatment with a colder liquid following a hot bath.

In the "Reuping" process the method is entirely different. The preliminary steaming is omitted. Before being placed in the cylinder, the timber is thoroughly air dried. Air is then pressed into the timber at a pressure of about 75lb. until the wood structure is partly filled with compressed air, then, still keeping up this pressure, creosote is admitted into the cylinder at a somewhat stronger pressure. After the timber is entirely covered the pressure is increased to 225lb. per square inch, which causes a penetration of the oil into the wood structure. The creosote is then removed, thus relieving the pressure on the wood, which permits a part of the preservative to be pressed out of the wood by the compressed air within. This method has an advantage in using only a small amount of preservative.

Another method which is unique is the "Wellhouse." The preservative fluid which is used is zinc chloride. As stated before, this preservative has the disadvantage of being leached out in moist situations. However, this process overcomes that difficulty. Before the zinc chloride solution is pressed into the timber, it is mixed with one-half per cent. solution of glue. Later a tannin solution is forced in by a separate treatment. The effectiveness of this process depends upon the formation of a "leatheroid" substance in the cell openings which prevents the leaching out of the zinc chloride.

There are various other processes, each of which has its good points ; most of them are, however, quite similar to those already described.

In the treatment of mine timbers, a saving is not only afforded the consumer, but the supply of timber is also conserved for the country in general. As the more valuable species of timber become scarce, there is a constant tendency to substitute the inferior species of wood. This is being made possible by wood preservation, which not only increases the length of life of the timber, but also gives the consumer a much wider field to select from. Many woods which without treatment are almost worthless can be made serviceable by proper preservative treatment.

According to the Forest Service, the life of a mine prop has been estimated at approximately three years. It has been found that by treating, these props can be increased in length of life to thirteen years. From these figures it is easily seen how much of a saving may be effected through the use of preservative methods. As yet actual experiments in treating mine timbers have not been conducted with a large variety of species, however, there is an unquestionable saving for mine operators if they season their props before using, and a great saving if, in addition to that, they treat the timbers with a preservative, preferably creosote.

PUMPING PLANT AT SLOSS IRON MINES, U.S.A.

Owing to a shut-down of these mines being caused in 1909–10 due to an inrush of water brought about by heavy falls of rock, an electrically-driven pumping plant was installed. According to *Power* (New York), a 750 k.w. 2,300-volt 60-cycle turbo-alternator was installed in a generating station on the surface. From the switchboard the current is taken to the mine head by an overhead line, and thence through a three-conductor lead-covered steel-armoured cable to the pump motors. There are two 10-in. four-stage centrifugal pumps, each direct-coupled to a 450-h.p. squirrel-cage induction motor. The underground pumping station and a permanent sump of 1,500,000 gallons or more are situated about 1,600 feet from the slope mouth. At this point the pumps have to work against a total vertical head, including suction, of 655 feet. The rated capacity of each pump at 1,130 r.p.m. is 1,800 gallons per minute. Electrically, there was some difficulty at the start, due to resonance effects, which produced pin-hole punctures in the insulation of the motor windings. This difficulty, however, was remedied by earthing the neutral point of the generator and installing aluminium-cell electrolytic lightning-arresters.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q.—*Describe with sketch what is meant by working coal on the "face," "on end," and half on.*" (*Submitted by* WELSH TYRO).

A.—Most coals in their structure show a peculiar jointly formation, known as "*cleat*," which is regarded by some as very similar to jointing, and by others as some peculiarity more of the form and nature of cleavage. The cleat consists of the coal being cut across by two sets of parallel planes running perpendicular to the roof and floor, and more or less perpendicular to each other. In one direction the cleat is much more pronounced than in any other, by showing the face of the cleavage planes more or less bright and shiny. The set of divisional planes traversing the coal seam at right angles to the roof and floor is the most important, the formation being probably brought

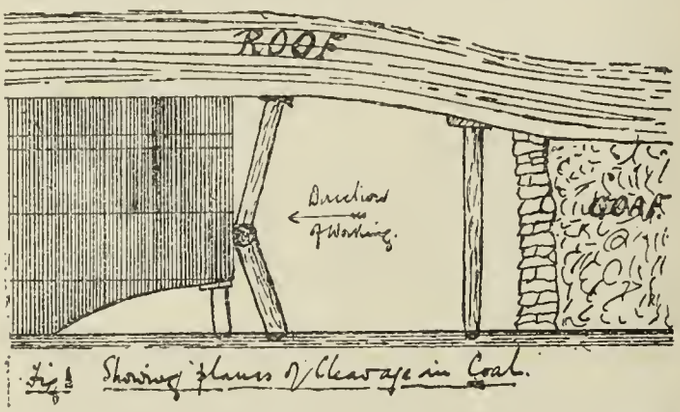

Fig 1. Showing planes of Cleavage in Coal.

about by pressure. Reference to *Figure 1* will show the cleat of the coal, the vertical lines representing the planes of cleavage, and the horizontal lines showing the planes of stratification.

It has been said that *most* coals show the formation of cleat; it is probable that all coals possess the peculiarity, but whilst the planes of cleavage may be very incipient in some cases, as in some of the Welsh coals, such planes are very pronounced in other coals, as in the Midland coalfield and Yorkshire. It

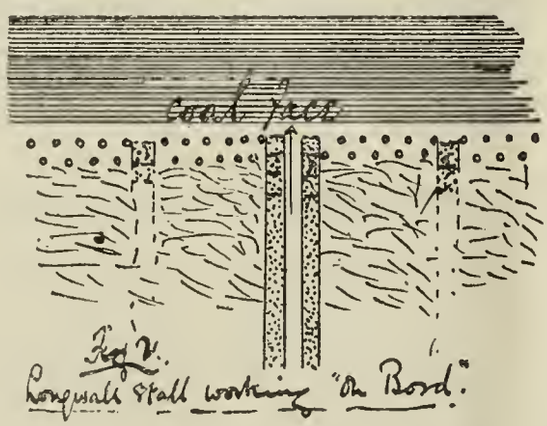

Fig 2. Longwall Hall working "On Bord."

is also very probable that the planes of cleavage, whether incipient or pronounced, exist in the roof strata overlying the coal, in exactly the same manner and in the same direction as the planes of cleavage in the coal seam itself. This is only what one might expect, and it is just as feasible to assume that the planes of cleavage in the coal and those in the roof strata were produced by the action of the same force. What that force was or how it was produced does not really matter, but according to geological theory it may be assumed that the force acted laterally, and at right angles to what are now the planes of cleavage, and that such a lateral force may have been produced by shrinkage of the earth's crust.

What importance is attached to the cleat in ordinary working? The cleavage of the coal and the direction of dip are probably the two most important objects to be considered when setting out a "face of work." In some districts the effects produced by one may be accentuated by the effects produced by the other; whilst in other districts the effects produced by one may be counteracted by the effects produced by the other. The effects produced depend on the angle with which the line of dip and the line of cleavage intersect each other. Workings advancing across the cleat, *i.e.*, across the planes of cleavage, are known as "bord workings," and the direction of working is said to be "on the bord," "on the face," or "bordways." *Figure 2* shows a sketch plan in which the coal face is marked by its planes of cleavage, and the direction of the working, as shown by arrow, shows the face to be advancing across the "face" of the divisional planes, or at right angles to the direction of the cleavage planes. *Figure 3* indicates the face advancing on the "end" of the divisional planes, or in the same direction as the cleavage planes. If the coal face is set out in any oblique or "cross-cut" direction between "bord" and "end," it is said to be on the "cross," or "horn." When the face is laid out at an angle of 45° with the line of cleavage it is said to be worked "half-on," or "half end and half bord." In the Midland districts the coal face is said to be on the "long horn" if it advances at an angle of less than 45° with the line of cleavage, *i.e.*, the face lies more bord than end; when the angle with the line of cleavage is more than 45°, the face lies more end than bord, the face is said to be on the "short horn."

What is the effect of the cleavage in these different lines of face? Consider a face advancing on the "bord" (*Figure 2*). It can easily be seen that the weight of the roof acts in such a manner as to split the coal along the divisional planes, and helps to bring the coal down more easily than in the *end* workings, where it can be seen the weight acts on the ends of the divisional planes (*Figure 3*). A study of the conditions of long wall working will reveal two component forces, a vertical force and a lateral force, acting on the line of face. These two forces can be resolved into one common or resultant force acting in some oblique line from above the coal to the centre of the space provided in the working. It is quite evident that if the face advances "on the bord," the planes of cleavage in the coal and the overlying strata running continuously along the face-line and parallel to that line, the planes resemble "lines of least resistance," and give a natural assistance to the vertical component force, tending to crush the coal down in long slabs or

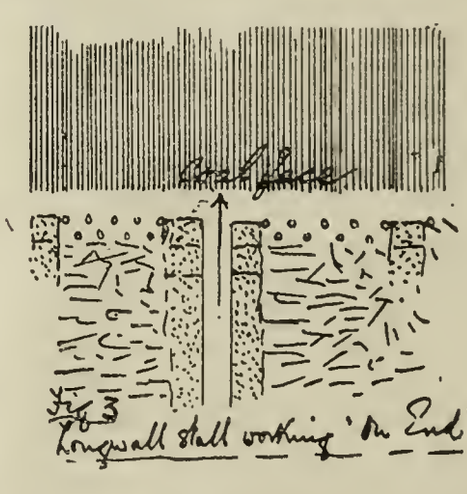
Fig 3 Longwall Hall working "On End."

slices. With a strong coal and a strong roof it may be an advantage to work the coal "on the bord"; but in many cases the roof action is too severe, and since it attacks the "slices" of coal along the lines of least resistance a weak coal, or even a moderately strong coal, may be crushed unduly, producing an abnormal amount of small coals. Or again, where the cleavage planes are very pronounced, and the roof pressure abnormal, the action may be so severe as to break off the roof along the face line with the result that the required roof action is lost, and the coal becomes toughened. When the direction of working is "on end," *i.e.*, in the same line as the cleavage planes, the conditions are entirely different because then the

roof action only bears on the "slices" in the same direction as their lengths, the resistance offered is greatest, and only the short bridge across the face of work, which, however, is at maximum strength, is subjected to any great pressure. In this direction the labour of getting the coal is materially greater, but the coal is won in a better round condition. Where in bord working the slabs or slices fall away from natural planes when the cleavage is pronounced, in end working the slices cannot fall away but must be literally broken through at some angle to their length.

In some seams it is found advisable, in order to prevent the violent action of the roof pressure continually breaking the roof away along the coal face, to lay the workings out in what is known as "step" working, or "stepped long wall." In this system all the advantages accruing from "bord" working can be gained and at the same time the action of the roof pressure along the coal face minimised by diverting it along a *mean* line. The faces may advance "bordways," leaving at one side a face of coal "on the end," known as the "wall-side," but each face should lead the next behind it by some definite and regular distance. The draws due to the "bord" and "end" respectively will resolve themselves into one common draw, resulting in a "mean face line" crossing the faces diagonally. The proper direction of this mean face line will, of course, depend on the length of bord faces and the distance of lead between one face and the next.

No hard and fast rule can be laid down for any seam as to any particular direction of working, but it is usual according to previous experience of a seam, or to the apparent nature of the seam, to open out either on "bord" or on "end," and then to bring the direction to the most suitable angle with the planes of cleavage as experience teaches, or to adopt the "stepped system." It is one of those things in a mine which only the experience of the management with the natural conditions "on the spot" can definitely decide. It might be mentioned that, in "bord and pillar" working, the "bords" are usually driven across the cleavage planes, *i.e.*, on the "bord," when the "walls" will be driven on the "end."

Q.—*The winding space in a shaft is 8 feet × 6 feet. The doorheads are 7½ feet high. Find the length of the longest "stick" that could be taken into the mine.* (*Submitted by* A Pit-Bottomer).

A.—The question is not very clear. If A Pit-Bottomer means, what is the distance from one corner on the horizontal level of the doorway diagonally across the rectangle to the top corner on the other side, then it may be found by the following rule :—

Length $= \sqrt{8^2 + 6^2 + 7{\cdot}5^2} = \sqrt{64 + 36 + 56{\cdot}25} = \sqrt{156{\cdot}25} = 12{\cdot}5$ feet.

This rule, length diagonally from bottom corner on one side to top corner on other side, is based on this :—Taking the horizontal level of the rectangle as 8 feet × 6 feet, a diagonal across the centre on the base will be the hypotenuse of a right-angled triangle whose base and perpendicular are 8 feet and 6 feet respectively. Then diagonal on level $= \sqrt{8^2 + 6^2} = \sqrt{100} = 10$ feet.

Now, the longest distance is the hypotenuse in which the base is taken as 10 feet, and the height 7 feet 6 inches. (Height of doorhead). This is

Length $= \sqrt{(7{\cdot}5)^2 + 10^2} = \sqrt{56{\cdot}25 + 100} = \sqrt{156{\cdot}25} = 12{\cdot}5$ feet.

This distance is the longest distance to be obtained at the shaft level, but may not necessarily be the length of the longest "stick," for such will depend on the thickness of the "stick." The length may be taken as the maximum.

Q.—*If 30,000 cubic feet of air per minute is passing through the workings of a mine with 0·9 inch of water-gauge, what would the quantity be if the water-gauge was increased to 2·0 inches, the air-ways remaining the same?*—(*Manchester Second Class Exam.*)

A.—Other things remaining the same, quantity varies as $\sqrt{}$ pressure.

$\sqrt{0{\cdot}9} = 0{\cdot}9487$. $\sqrt{2} = 1{\cdot}4142$.

$$\therefore \text{New quantity} = \frac{1{\cdot}4142 \times 30000}{0{\cdot}9487}.$$

$$\therefore \text{New quantity} = \frac{42426}{0{\cdot}9487}.$$

New quantity = 44,720 cubic feet per minute.

SURVEYING.

By COLLIERY SURVEYOR.

Scales.

The representative fraction of a scale is the ratio between the length denoted on the plan and the actual length which it represents. Thus in a plan drawn to a scale of one inch to the mile the one inch on the plan is understood to represent one mile, *i.e.*, 5,280 × 12 = 63,360 inches; the representative fraction is, therefore,

$$\frac{\text{Length on plan}}{\text{Actual length}} = \frac{1}{63360}.$$

When a scale is drawn with equal divisions only, it is called a plain scale. Two dimensions are obtainable from such a scale, while from the diagonal scale three dimensions may be obtained, though it may happen that a diagonal scale is constructed to show two dimensions only.

To be of proper service, scales should fulfil the following conditions: (*a*) They should be divided with great accuracy and carefully numbered. (*b*) They should be long enough to measure the principal lines of a drawing or plan. (*c*) The zero should always be placed between the unit and its sub-divisions. (*d*) The name of the scale should be written upon it, and the representative fraction shown.

Examples to be Worked Out.

Readers working out the appended questions and who desire a test of their ability, should submit their answers to Colliery Surveyor, care of *The Science and Art of Mining* Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means answers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonies and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to Colliery Surveyor at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the regular series of articles.

1.—*Determine the azimuth and length of the straight line joining the two ends of the traverse recorded below :—*

Line.	*Azimuth.*	*Hor. Distance.*
1 ..	130°09′ ..	389·5 feet.
2 ..	120°33′ ..	631·0 ,,
3 ..	124°39′ ..	381·2 ,,
4 ..	160°34′ ..	752·5 ,,
5 ..	191°54′ ..	157·9 ,,
6 ..	265°03′ ..	277·0 ,,
7 ..	353°47′ ..	652·0 ,,

City and Guilds, Grade II., 1912.

2.—*Survey station* A *has its Northing = 424·4 feet, its Easting = 213·7 feet, and its height above Ordnance Datum = 260·8 feet. Survey station* N *has its Northing = 1728·6 feet, its Easting = 9263·4 feet, and its depth below Ordnance Datum = 763·2 feet. Find the length, azimuth, and inclination (or gradient) of the straight line from* A *to* N. (*Ibid*).

3.—*From the top of cliff, 130 feet high, the ∠s of depression of two boats are 57° and 49° ; if they are in a direct line with the foot of the cliff, determine by any method you wish the distance between them.*

4.—*As I walk along a straight road I notice a church whose direction makes an ∠ of 18° with the road ; one mile further on its direction makes an ∠ of 72 °. What is the shortest distance of the church from the road?*

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GLAMORGAN COUNTY COUNCIL.

APPOINTMENT OF LECTURER IN MINING.

The Education Committee Require the Services of a MINING LECTURER.

The candidate appointed must be qualified to teach the subjects of the Glamorgan Mining Course ; must reside where directed by the Committee, and devote his whole time to his duties.

Salary, £150 per annum, rising by annual increments of £10 to a maximum of £200 per annum, together with travelling expenses according to scale.

Canvassing directly or indirectly will disqualify.

Applications, made on forms which may be obtained on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, COUNTY HALL, CARDIFF, not later than the 18th June, 1912.

The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, JUNE 8, 1912.

ROCK-DRILL DUST COLLECTOR.

Two mechanics in the employ of the De Beers Consolidated Mines have invented and patented a device for collecting the dust produced by rock drilling and preventing its diffusion into the atmosphere. According to the *South African Mining Journal*, the contrivance has been tried at De Beers under working conditions, and has answered the tests. "The apparatus consists chiefly of a steel casing, small in diameter and cylindrical in form, and weighing about 5lb. This is meant to surround the drill at the working face. It opens in two—the halves being connected by hinges—so that the drill may easily be changed or adjusted. Each half of the casing has a dust collecting chamber, which can be fitted either with a lid or a removable bag. The device can, therefore, be used no matter what may be the angle at which the drill is being worked. Running round the front of the casing is a groove into which rubber is fitted for the purpose of pressing against the rock face, and thus preventing any escape of dust between the rock and the casing. In consequence of this, the dust, it is claimed, passes back into the cylinder and falls into the dust collecting chamber. The casing is supported on telescopic piping, which is fastened to the cradle of the drilling machine by means of a clamp. The outer piping is perforated, so that by the use of a pin the inner tubing can be adjusted to the length of the drill in operation."

A SOUTH AFRICAN COLLIERY.

The Clydesdale Company's colliery at Coalbrook, in the Orange Free State, has been visited by members of the Chemical, Metallurgical and Mining Society.

The following is a description of the property :—

The Coalbrook Colliery is situated on the farm Taaiboschspruit, district of Heilbron, Orange Free State, about five miles south of Coalbrook Station, on the main line of railway from Germiston to Bloemfontein. Coalbrook Station is thirteen miles south of Vereeniging.

Coal has been proved in seven bore-holes, over a very large area, the life of the mine being practically unlimited.

Sinking.—Work was begun in the year 1904, two shafts being sunk to the coal which was entered at 437 feet 3 inches from the surface and passed through at 470 feet, the shafts being stopped in conglomerate at a total depth of 487 feet 3 inches ; the coal seam is 32 feet 9 inches thick. The section to the coal shows sandstone, dolerite, shales and conglomerates ; the dolerite is 77 feet 4 inches thick, and sinking in it was difficult and costly. The coal was cut in the shafts in January and March, 1905, respectively, and an output was begun in April of the same year ; the mine has been worked regularly since, and the output now averages 11,000 to 12,000 tons per month.

Ventilating Plant.—This consists of a high speed Waddle fan 21 feet in diameter, capable of running at 100 revolutions and producing 100,000 cubic feet of air per minute. The fan is direct driven by a steam engine.

Banking and Screening.—The banking is done at one level and the tubs are turned on to jigging screens which separate the small coal, the large coal passing over to the main belts where it is cleaned, the inferior coal and shale being passed down shoots to a travelling belt. The cleaning belts are of the bar pattern, and are each 71 feet in length.

Washing Plant.—The whole of the small coal is carried by conveyor belts and an elevator to the washing tank, which consists of three Bash tanks and a Felspar washer. The small coal is sorted through a revolving screen into three sizes—nuts, peas and pearls, before washing. All these qualities are loaded direct into wagons from the hoppers under the washer. The small coal refuse passes along launders and through pipes into the settling ponds, the water being pumped back by a centrifugal pump.

Electric Lighting and Power Plant.—A complete lighting and power plant has been recently erected.

Generating Plant.—This consists of :—One 220 B.H.P. Bellis and Morcom 2-crank compound engine running at 425 R.P.M., at present exhausting into the atmosphere. Direct coupled to one Johnson and Phillips continuous current 3-wire generator. The generator is 5 per cent. over compounded, and has only one commutator and three slip rings. The potential difference at the brushes on the commutator is 500 volts at no load, and 525 volts at full load, and the normal full load output is 300 amperes. From the three slip rings a three-phase current is taken to three choking coils immersed in oil. The choking coils are connected in star, and from the star-point the neutral wire is taken. This is earthed at the main switch-board end, and the voltage between any one of the two outers and the neutral is 250/262½ volts. All the motors are connected on the outers, and they are, therefore, ordinary D.C. 500-volt machines. All the lights on the other hand are connected between any one outer and the neutral, 250-volt lamps being employed.

Motors.—There are two 80-h.p. motors, compound wound, one for driving the screening plant, one for driving the washing plant. The washing plant motor is fitted with a speed regulating device which permits of running the plant from zero up to the full working speed. There is a 50-h.p. motor driving the underground haulage, a 25-h.p. motor driving one Gould's triplex pump, 6 inches by 8 inches, a 16-h.p. motor driving the workshops, a 5-h.p. motor driving pump 1½ miles distance, and one 25-h.p. motor driving compressor underground. In the engine room there is a main lighting and power distribution switchboard. The leads of the 80-h.p. motors and of the underground power supply are made by means of paper insulated and lead covered cable. Each motor is protected by Ferranti automatic

overload switches, and the motor circuits themselves are protected by Ferranti type non-arcing fuses. There is no porcelain about these fuses, and they are removed by means of a handle specially provided for the purpose.

Lighting Plant.—All the buildings on the property are electrically lighted, the protective fuses being placed in centrally arranged positions, eleven to twelve lamps being the maximum on any one circuit.

The main drives underground have been well lighted with lamps 40 to 50 feet apart. Each group of lamps, from 15 to 20, being protected by their own cartridge type fuse placed in a cast-iron water-tight switch and fuse box. This arrangement is particularly valuable in a coal mine where the wires are loosened at times through the hanging wall coming down. In such a case only the lamps on that one circuit affected by the fall go out, not affecting the whole plant.

Telephones.—A telephonic installation has been installed all over the property and underground.

Boiler House.—Five Babcock and Wilcox water tube boilers, each 110-h.p., have been erected: they are hand fired, and are each capable of evaporating 3,500 gallons of water per hour. The feed water is heated by the exhaust steam from the winding and electric engines.

Shops.—These consist of fitter's, blacksmith's, carpenter's and electrician's shops. They are fitted with sawing, wood morticing, lathe, drilling, punching, shearing, and screening machines, also a power hammer; all of which are driven by a motor.

Underground.—The coal is 32 feet 9 inches thick, but only the lower portion averaging 9 feet is being worked. The seam is worked on the pillar and stall method. The mine is laid out on the panel system, to allow of the sealing up of any section in case of need. The benching method of breaking the coal is adopted, there being a good holing about 5 feet from the pavement; the coal breaks large and cleanly. The measures dip slightly south west and the main drives, which run east and west, are fitted with mechanical haulages driven by a 50-h.p. motor. A number of mules are used to draw coal to the main haulages. The mine makes very little water, about 3,000 gallons per day, which is dealt with by a Gould pump.

ELECTRICITY DIRECT FROM THE COLLIERY.

The plans of the Lehigh Navigation Electric Company, Philadelphia, Pa., include the erection of a generating station near the coal mines at Hauto, Pa., and embody one of the most important steps towards the economical use of coal without transportation, and the transmission of electrical energy on a large scale so far undertaken in the United States. The site of the central generating station, according to the *Engineering Times* correspondent, is about ten miles west of Mauch Chunk at the mouth of a railroad tunnel leading to the main body of anthracite coal owned by the Lehigh Coal and Navigation Company. From this point the energy for heat, light, and power will be distributed by high voltage transmission lines extending throughout Eastern Pennsylvania and New Jersey, and covering a territory with a population of 2,500,000. The company have a waste production of about 500,000 tons of coal a year consisting of coal dust and particles which will pass through 0·1in. mesh screens, but in the present scheme this refuse, which is not marketable, will be consumed under the company's boilers. The choice of Hauto as the site for the main generating plant was also influenced by the fact that an abundant water supply was available, as the plant to be employed ultimately will require about 300,000,000 gallons a day. To provide this amount the capacity of an existing reservoir is being increased by the construction of a higher dam to 1,000,000,000 gallons with an area of 400 acres. The *maximum* output contemplated will be 100,000 k.w., and it is estimated that 1,000,000 tons of coal a year will be required, a quantity which would require 20,000 of the largest cars to transport to market. It is proposed to supply energy to the slate and cement industries in Lehigh and Northampton counties, all of which are in a territory from 20 to 40 miles distant from the Hauto plant, and probably substations will be established at once in the heart of these two districts to step down and distribute the energy to users. There are about 20 large cement mills within a radius of 75 miles from the main station. The transmission lines will be erected along the Lehigh Navigation Canal, and also on the right of way of the Lehigh and New England Railroad, which the company control, and in this way but little property will have to be acquired for the pole lines. With the assistance of these companies a complete census of the motors used in the industries has been taken, and it has been found that within the district which will be reached by the first section of the Hauto plant power to the extent of over 100,000 h.p. is being employed. The Lehigh Navigation Electric Company have prepared a schedule of rates running from eight mills up to 2½ cents. per k.w.-hour, according to the amount of power contracted for and the steady rate of consumption, and at these prices the company will deliver energy materially under the cost at which the industries are able to produce steam power. According to present plans the first installation at the Hauto plant will be in operation before the end of the year. The company have arranged for an initial expenditure of $3,000,000, and an order has been placed for three 10,000 k.v.a., 11,000 volt, three-phase, 25-cycle horizontal turbo-generating units, complete with three 300 k.w. turbo-exciter sets and one 300 k.w. motor-generator exciter set. The equipment of the plant will be increased gradually, the expectation being to supply energy to Allentown and Easton, Pa., to Trenton, N.J., and finally to Philadelphia, which is within 80 miles of the Hauto plant.

SOUTH WALES MINING EXAMINATIONS.*

Mines Act.

1.—State the Act regarding the absolute prohibition of certain explosives in mines.

2.—What are the regulations in regard to the provision of manholes in ordinary roads?

3.—What are the provisions in the Act relating to single shafts?

4.—Under what conditions is the use of detonators absolutely prohibited?

Maximum marks 20.

Arithmetic.

1.—A colliery has an area of 580,800 square yards, the seam is 4 feet thick, yield 4,800 tons to the acre. What is the total yield in tons?

2.—A tank 14 feet wide by 10 feet long has a capacity of 31¼ tons of water. Find the depth of tank.

3.—A square field has an area of 99,856 square yards. What is the length of one side?

4.—Divide 438·76 by 63·27.

Maximum marks 20.

Methods of Work.

1.—Sketch and describe the system of main and tail haulage.

2.—Under what conditions is the machine cutting of coal preferable to hand-cutting?

3.—Sketch and describe the different kinds of air-crossings, and give your opinion of them.

4.—What precautions would you take in driving towards old workings containing water?

Maximum marks 50.

Ventilation.

1.—What is the principle of the centrifugal fan?

2.—What are the chief points to be noted in the ventilation of an extensive colliery?

3.—How do you find the horse-power obtained by the fan?

4.—What approximate percentages of gas can be detected with a Marsaut safety-lamp?

5.—Find the weight of a cubic foot of air and fire-damp at its most explosive point when the barometer is 30 inches, and the thermometer 60.

Maximum marks 50.

Viva Voce.

1.—How would you tell if the ventilation was efficient?

2.—What are the essential conditions of safety at the coal face?

3.—What do you understand by systematic timbering?

* Second Class Questions at Cardiff in May, 1912. The contributor does not vouch for the accuracy of the phraseology, but the figures are correct.

PRIZE COMPETITION.

" Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, June 18th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 23, Vol. XXII., but in No. 24, Vol. XXII.]

PREPARATORY.

Q. 1. TIMBERING.—*Give your views on the question of timbering at the working face in a seam about 6 feet in thickness.*

Q. 2. GASES IN MINES.—*What do you know about the law of the " diffusion of gases " and its effect on their behaviour in mines?*

Q. 3. SHOT FIRING.—*In electric blasting what are the chief causes of miss-shots?*

Q. 4. PUMPS.—*Describe the working action of a forcing pump.*

SECOND CLASS.

Q 5. PUMPS AND PUMPING.—*Three parallel places being driven to the dip are much troubled with water. The dip is 1 in 9. State how you would keep the faces clear of water.*

Q. 6. METHODS OF WORKING.—*In a seam liable to spontaneous combustion it has been decided to remove the pillars. The seam is 9 feet thick. Describe fully the points to which you would direct special attention.*

Q. 7. MINE GASES.—*Explain why, although gas may burn explosively inside the gauze of a safety-lamp, it will not ignite the same mixture outside.*

Q. 8. COMPRESSED AIR.—*Recognising the losses arising in the use of compressed air, state generally what arrangements you would adopt with a view to obtaining the best results.*

FIRST CLASS.

Q. 9. SURVEYING.—*The workings of a colliery operated by shafts extend over an area of 500 acres. A new plan is found to be necessary, requiring a re-survey of the surface boundaries and underground workings. Describe how you would carry out this work.*

Q. 10. COLLIERY RE-OPENING.—*You are called upon to supervise the re-opening of a colliery which has been sealed owing to fire. The seam is very fiery. How would you proceed?*

Q. 11. ROPES.—*Give sketches of a socket for a winding rope, load 10 tons.*

Q. 12. ELECTRICAL APPARATUS.—*Describe the apparatus necessary for electric signalling on a plane 3 miles long. What precaution would you take in fixing same in a gassy mine?*

Best Answers Received to Questions In No. 20, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Coal Mines Act.

Q. 1.—*In your own words what are the requirements relating to inspection of machinery?*

A.—Machinery is employed for different purposes, both above and below ground, in connection with collieries. It is evident that such machinery will require periodical inspection, both from the point of view of safety and economy, if it is to be used to the best possible advantage. Knowing the advantages to be derived from the inspection of anything in operation connected with mining, as regards safety, it is highly imperative that machinery should receive periodical and thorough examination from authorised and experienced persons.

The requirements of the C.M.R.A. relating to inspection of machinery are imperative, and make it incumbent upon the management to make provision by appointing special persons for the examining of any machinery in use above and below ground, and report as to the condition of such machinery.

General Rule 5 of the C.M.R.A makes it incumbent upon the management to appoint competent persons to inspect and examine all external parts of machinery that may be used in the mine, and all pulleys, wheels, &c., in connection with the shaft for the raising or lowering of persons. This inspection shall be made at least once every 24 hours, and the person making the inspection shall make a true report in a book provided of the actual condition of such machinery.

Where a fan is used for producing ventilation in any mine, the under-manager is required to inspect the same occasionally, and satisfy himself that it is in good repair and attended to.

The periodical inspection of all surface machinery is necessary, hence we find that the C.M.R.A. requires such machinery to be under the charge of a special engineer, or other competent person, appointed by the management. He is expected to exercise special supervision over all machinery under his charge, and inspect the same at all times, keeping it in thorough and efficient repair. He must make any defective machinery right, and make a report of the state of machinery, as required by General Rule 5. The engineer is required to give special instructions to persons in charge of machinery as regards periodical inspection, so that everything in connection with machinery can be utilised to perfection and with safety.

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

Each person in charge of machinery, say winding engines, pumps, or any other machinery, is required to pay special attention to it. He must make a thorough inspection and examination of all parts in connection with it at least once during his shift. Should he find anything defective after inspecting the same he shall report the defects to the engineer or superior officer.

Persons in charge of appliances and machinery for generating steam, &c., are required to exercise special supervision and inspect all external parts for the safe working of the same during the working shift. Competent persons are required to examine such machinery and appliances internally after cleaning and repairing, and make a true report of the conditions.

Thos. Gaskell, 138, Downall Green Road, Bryn.

C. Simpson, J. C. Rodman, I. Hollins, F. Mitchard, J. Taylor, W. Williams, T. Garbett (*12 marks each*).

J. Smith, Junr., L. J. Thomas, J. Brooks, S. F. Middup (*8 marks each*).

C. E. Morgan (*4 marks*).

Rescue Work.

Q. 2.—*What is your opinion as to the value of rescue apparatus underground?*

A.—One result of recent colliery disasters has been to bring into prominence the various forms of rescue apparatus. Much has been said for them and much against them. In the first place they only come into use when the amount of gas present in the mine is such as will overcome any living creature. On the face of this it seems that there is no useful purpose served in hurriedly sending men down the mine which is filled with various gases in the forlorn hope of rescuing any one. From the records of the large explosions I find that very few have been rescued by the aid of rescue apparatus. In such circumstances, therefore, especially after the large coal dust explosions when we have the mine filled with poisonous gases, it is a most forlorn hope to even think of rescuing any one from the mine with the most perfect of rescue apparatus.

In other circumstances we may find a use for them. Take, for instance, a small outburst of poisonous gas by which a person is overcome, as sometimes occurs, and which is a local disturbance. Then by the use of apparatus it is probable that the person affected may be rescued. To do this, however, we should need to have the apparatus ready for use, and it is more than probable that this would not be the case. When dealing with gob-fires they may prove their usefulness in saving life by keeping them in readiness for use. I myself in such circumstances, if the fire was of any extent, would allow one set to be held in readiness for use to deal with any emergency, such as the overcoming of a workman by poisonous gas.

From the above I look upon the rescue apparatus as of little value underground in saving life. On the other hand, they have been found of value in saving property, and recovering the victims' bodies. After an explosion they have been used, and by their aid the ventilation has been restored and steps taken to put the mine in proper order. Those connected with the mine have not to wait until the gas has cleared away before they can find out the condition the mine is in. Also the relatives of the victims are not kept in suspense for so long a period as before.

If, however, the whole mine does not suffer, and the explosion is confined, it is possible that the workmen may be saved by their use. In dealing with a large underground fire the men are enabled to get to close quarters with it, and are thus better able to deal with it owing to the gas given off having no effect on the men.

Jesse Smith, 45, Archer Street, Ilkeston, Derbyshire.

[NOTE.—It is rather a hard and certainly a very disappointing admission, but the general opinion is to the effect that the use of rescue apparatus underground is of slight practical value, at any rate as regards the saving of life. It is quite true that only a few days ago after an explosion in a sinking pit in Monmouthshire which involved the loss of at least five lives, it was found possible to rescue one man by the aid of breathing apparatus, but when we consider how different are the conditions in a sinking pit from the extensive workings of an ordinary colliery, we do not see much ground for believing that such or similar apparatus will be of much use for saving life. In another respect we believe that these apparatus will prove to be distinctly useful, namely, in the restoring of a mine to its normal condition after an explosion or fire. The reason we do not think these appliances will be of much use for saving life is: Seeing that they are for use in air unfit to breathe and incapable of supporting life, it is only reasonable to presume that the victims are exposed to this same atmosphere for a long time before their would-be rescuers can possibly get to them, and their chances of being rescued alive would be practically nil. As regards restoring the mine, these appliances would enable the workers to build stoppings, air-crossings, erect doors, and brattices in an atmosphere unfit to breathe, and so restore the mine to its proper condition. This is, of course, our opinion, but it is held by many prominent men in the mining profession.—C.C.M.]

C Simpson, J H. Spence, T. Gaskell, J. C. Rodman, I. Hollins, L. J. Thomas, F. Mitchard, A. E. Helps, J. Taylor (*12 marks each*).

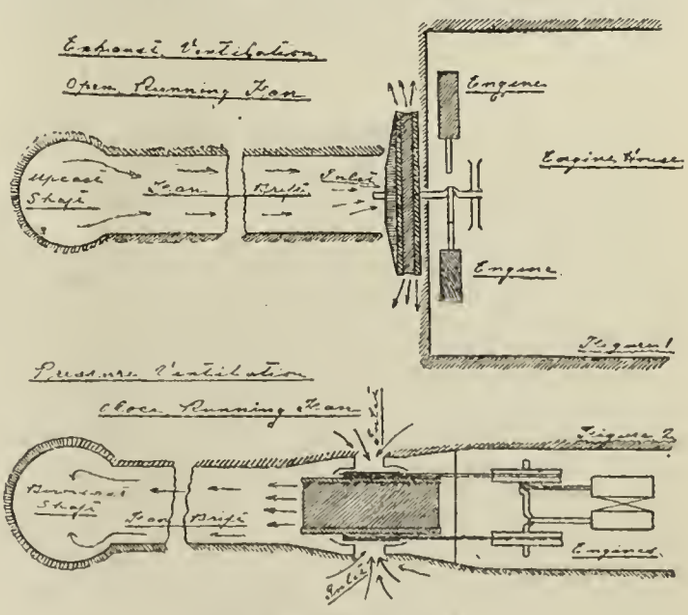
W. Williams, J. Brooks (*8 marks each*).

T. G. Lippitt (*4 marks*).

Ventilation.

Q 3.—*Explain the action of the forcing fan and the exhausting fan in producing ventilation.*

A.—According to the 1st General Rule of the C.M.R.A. a sufficient quantity of air must be provided in every mine so that thorough dilution of the gases given off from the strata, &c., may be produced as far as possible. To bring about an efficient ventilation special means must be provided, and these means are the furnace and fan. After the 1st July furnaces shall not be allowed for ventilating purposes in new mines, therefore the production of ventilation shall rest solely upon the fan. The fan produces ventilation in two ways, viz., by pressure and by exhaust. It is well known that the circulation of a quantity of air through the roadways of a mine is brought about by a difference of pressure acting at the top of each shaft respectively. Assume we have two shafts of equal depth communicating with a mine, and it is required to ventilate the same. Then the pressure at the top of one of the shafts must be either increased or decreased. Should the pressure be increased the ventilation will be the "pressure" system, and should it be decreased the "exhaust" system will be in operation.



Illustrating Question 3.

Exhaust Fan.—When a fan ventilates by exhaustion it is so arranged that its centre is open to the upcast shaft. When in motion a partial vacuum is set up within the fan, which is immediately occupied by air from the upcast shaft by way of the fan drift being forced into this position by the superior

pressure of the atmosphere at the top of the downcast. The air in the centre of the fan is then expelled to its periphery, the power being centrifugal force, and from thence into the open atmosphere. As long as the fan revolves so long will the ventilation be kept up. The exhuast fan is very simple in construction, and may be of the close running or the open running type. All give great efficiency, and hold the advantage over pressure fans as they are more adaptable to the general working of a mine. *Figure 1* shows the Waddle fan. By reference to the same an idea of its principle of action will be gathered. It is open running, gives a high standard of efficiency, and when at work does not prevent the winding of coals, if necessary, by way of the upeast shaft.

Pressure Fan.—The action of a forcing fan is the opposite to the exhaust fan. The principle is the same, depending upon centrifugal force in generating and keeping in motion an air current, but as stated its general action is different. The forcing fan increases the pressure at the top of the shaft to which it is applied, thus it produces the ventilation by pressure, *i.e.*, increases the pressure above that of the atmosphere. It will be understood that a forcing fan must be close running. The fan's periphery is open to the shaft, which in this case will be the downcast, whilst its centre is open to the atmosphere. By reference to *Figure 2* its arrangement may be noted. When the fan revolves by means of the machinery, the air in the periphery (assuming the fan is full of air) is thrown off, due to centrifugal force. As its only way of escape is by means of the downcast shaft it is compressed into it, then through the mine roadways, &c., into the atmosphere by way of the upeast. As the air leaves the fan it tends to create a vacuum, but as the same is immediately occupied by air from the outside atmosphere, the current circulating is kept in motion.

Opinions vary as to which type of fan produces the better ventilation. Some favour the forcing, and others the exhaust. I should say that in ventilating a mine, that is, in producing an adequate current of air, both types are about equal. Yet the exhaust fan seems to hold preference, at least in this country, and the reason is greater simplicity in working; also it is more suitable as a ventilating means when the general working of a mine is considered.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

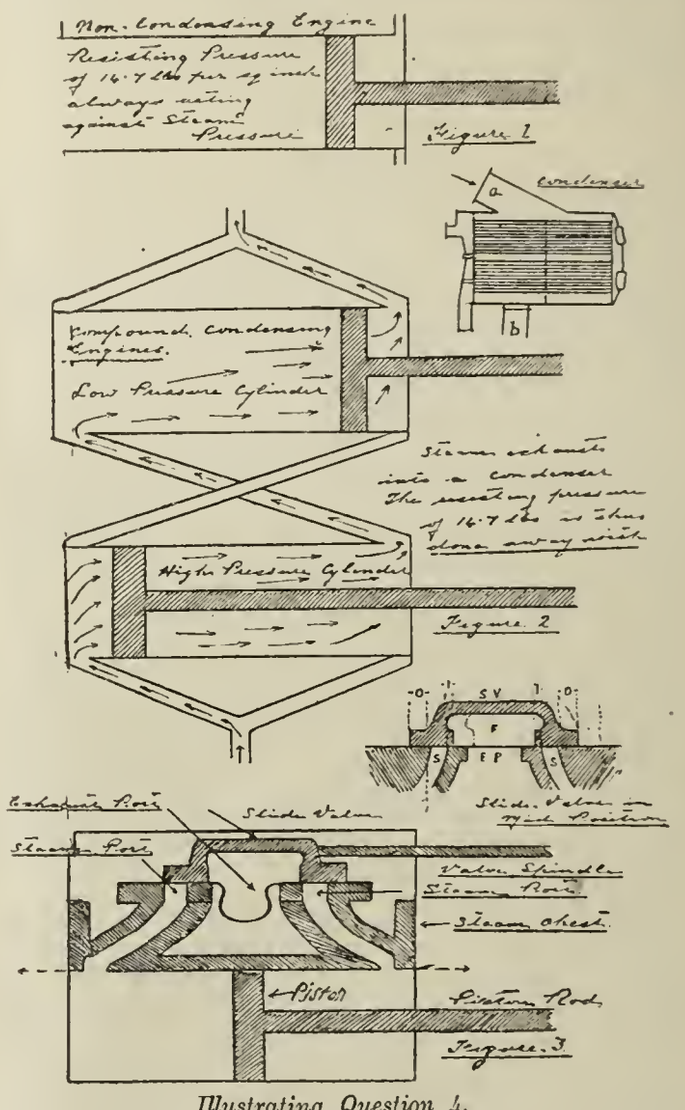
S. Beardsley, T. Gaskell, J. C. Rodman, I. Hollins, F. Mitchard, A. E. Helps, J. Taylor, R. Graham, W. Williams (*12 marks each*). C. E. Morgan, T. C. Lippitt, J. Brooks, L. J. Thomas (*8 marks each*).

Engineering.

Q. 4.—*What is meant by each of the following terms:* (a) *Indicated horse-power;* (b) *lap;* (c) *lead;* (d) *non-condensing;* (e) *compound condensing engines.*

A.—As a preliminary it will not be out of place to give a short description of the steam engine to which all the above-stated terms apply. It is known that the steam engine in its many forms is the agent by means of which part of the active energy stored up in the steam as supplied by a boiler is converted into mechanical or useful work. The steam is conveyed into a cylinder, and is there made to move a piston which in turn, through the medium of connecting rod, &c., is made to produce mechanical power. Since their invention the steam engines have been greatly improved. The admission and discharge of the steam to the cylinder is regulated by means of a slide valve, made to travel to and fro across the port openings by the action of an eccentric keyed to the crank shaft. The receptacle containing this slide valve is termed the steam chest. The pressure of the steam acting on the back of the valve keeps it in steam-tight contact with the working face of the cylinder. The cavity in the centre of the valve permits either steam port to communicate with the exhaust port. By reference to *Figure 3*, illustrating the slide valve and steam cylinder, an idea of the engine's principle of action will be gathered.

"*Lap*" *and* "*Lead*."—The amount by which the slide valve overlaps the outer and inner edges of the different steam ports when in mid-position is called the "outside" or "steam lap," and the "inside" or "exhaust lap" respectively. In the diagram given *O* is the outside lap, and *I* the inside lap. The object of the outside lap is to cut off the steam before the piston has reached the end of the stroke, so as to take advantage of the expansive energy of the steam, and thus to work much more economically than if the steam were admitted throughout the stroke. The inside lap acts in the same way with regard to the steam leaving the cylinder. A portion of the exhaust steam is retained and compressed by the piston, thus forming an elastic cushion, which assists in bringing the piston, &c., to rest without shock at the end of each stroke. The steam port *S* begins to open for the admission of steam just before the piston reaches the end of each stroke, so that at the commencement of a stroke the port is open by a small amount, which is called the "lead." The dotted lines show the valve in this position. Admitting steam on the exhaust side just before the end of the stroke completes the compression action, and the lead enables the full



Illustrating Question 4.

pressure to be brought to bear on the piston at the commencement of each working stroke. Near the end of the expansion or working stroke the slide valve is in such a position that the steam can escape through the cavity in the valve centre into the exhaust port *EP*. This port is called the "release." The driving pressure is thus relieved, and at the commencement of the return stroke, owing to the further motion of the valve, there is ample allowance for the exhaust steam to pass out of the cylinder without producing undue back pressure. It may be stated that a delayed release causes excessive back pressure and reduces the effective driving pressure of the steam. Modern engines work greatly on the expansion principle, the steam being cut off at a quarter, half, and so on of the stroke. A single slide valve is not suitable for a cut-off earlier than half stroke, therefore many engines have two sets of valves, one set working at the back of the other.

Non-Condensing.—With non-condensing engines there is always a certain amount of the useful effect of the steam acting

in the cylinder rendered waste. It is known that the atmosphere acts with a pressure of about 14·7lb. per square inch in everything it comes in contact with. Thus, when the full pressure of the steam is acting on one side of the piston of a steam engine there is a back pressure of 14·7lb. acting on the other side for each square inch of surface. In non-condensing engines this back pressure is always in evidence, and as will be seen, practically renders ineffective 14·7lb. steam for every square inch of piston. *Figure 1* illustrates such engine. the steam exhausting into the atmosphere. Say the steam pressure at the cylinders of a non-condensing engine is 40lb. per square inch, then owing to the back pressure above referred to due to the atmosphere the effective pressure will only be 40 — 14·7 = 25·3lb. It will be understood that there is a great waste of steam from a non-condensing engine.

Compound Condensing.—All modern engines are made on the above principle. There are two or more cylinders, one being termed the high pressure, and the other the low pressure, the latter, of course, being of much larger diameter than the former. If three cylinders are in use, then the centre one is termed the "intermediate" pressure. Steam is admitted into the high pressure cylinder, but at a certain point in its stroke it is cut off, and the remainder of the stroke completed by the expansion of the steam at the end of the stroke, instead of exhausting the steam into the atmosphere, exhausts it into the low pressure cylinder, and thus does more work before final exhaustion. In the case described the steam is discharged from the low pressure cylinder into a condenser. Thus the resisting pressure or back pressure due to the atmosphere is greatly reduced. By reference to *Figure 2* the principle of compound condensing engines will be seen and understood. The direction of steam passage and stroke is shown by the arrows. As stated, the steam is exhausted into a condenser (see figure), in which the steam is condensed by means of cold water, and a condition of affairs very near to a vacuum produced. Thus, with the same pressure from the boilers quite 14lb. more effective pressure will be derived per square inch. In the condenser shown the steam enters at *a* and passes over the outside of a number of thin brass tubes about threequarters of an inch in diameter, through which cold water is kept circulating. The condensed steam falls to the bottom, and is removed by the pipe *b* by means of an air-pump. The water passes first through the lower half of the tubes, then through the upper half. The condensed steam causes a vacuum, and does away with the back pressure due to the atmosphere above referred to. In compound engines steam is used expansively, thus a great saving in steam consumption is obtained. By this is meant the cutting off of the full pressure of the steam at quarter length, half length, &c., of the stroke, the remainder of the stroke being completed by the expanding steam at a reduced pressure. An explanation *re* the using of steam expansively may be gathered by reference to page 254, No. 11, of the present volume of this Journal. Although with compound engines a great saving of steam is obtained, it must not be taken that an equal horse-power will be obtained in a pair of engines worked high pressure throughout. In the case of an engine cutting off at one-quarter stroke the average pressure will be about half the initial pressure, therefore, with one-quarter the steam there is obtained one-half the work. Thus there is derived an efficiency of two to one. It will be gathered that engines set to work expansively give great efficiency, especially where the conditions are favourable for the installing of a condenser, because then the efficiency will be greater still.

Indicated Horse-Power.—When a force is exerted against a resistance so that motion results, a certain amount of work has been accomplished. One pound weight raised one foot high equals a British unit of work equal one foot-lb. Of course, the amount of work is independent of the time it takes, that is, the shorter the time to do a certain amount of work the greater the power, and the longer the time the less the power. One horse-power is such power as can lift 33,000lb. one foot in one minute. The indicated horse-power of a steam engine may be calculated from the following formula :—

$$\text{I.H.P.} = \frac{PLAN}{33000}.$$

Where P = effective steam pressure per square inch;
L = length of stroke in feet;
A = area of piston in square inches;
N = number of strokes per minute.

An engine of say 200 I.H.P. would not efficiently deal with a load equal to the same, because a certain amount of the power is required to overcome its own resistances. Should the B.H.P. (brake horse-power) be equal to the above, then the work could be done, because the extra power used up by the engine in the working of its own parts would make this possible. Say 20 per cent. of the power is expended in overcoming the engines' own resistances, then the B.H.P. would be 160. Thus the engine would deal with work equal to the same. The indicated horse-power of an engine is the absolute total power the same is capable of giving, thus including with the outside work (B.H.P.) the inside work also.

In the preparation of the above answer I have been assisted by Nelson's *Encyclopædia re The Steam Engine* and this Journal.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

C. E. Morgan, J. H. Spence, T. Gaskell, S. F. Middup, J. C. Rodman, A. E. Helps, J. Smith, Junr. (*12 marks each*).

W. Williams, R. Graham, L. J. Thomas, T. J. Hay (*8 marks each*).

SECOND CLASS.

Geology.

Q. 5.—*Discuss the use of geology to the mining engineer.*

A.—The value of a sound knowledge of geology can easily be appreciated when we consider the great variety of products that we derive from the earth's crust. There is hardly a branch of engineering to which a knowledge of geology is not of assistance, but undoubtedly it is to the mining engineer that its reasonings and teachings are of the most importance. Geology concerns itself in the structure of the earth's crust, and the examination of its minerals, their relative positions, together with their mode of formation, and the laws that regulate their arrangement. We see that when we have gained a clear conception of the above we are in possession of knowledge that will greatly aid us in nearly all mining operations. When searching in unexplored countries for minerals the prospector cannot proceed with any hope unless he can clearly distinguish between the different rock formations, and is able to locate those which may yield the particular mineral he is in search of. When boring to prove the value of known seams in any particular district, again in putting down deep bore-holes, the mining engineer has to make a careful investigation of the surrounding district to ascertain the physical conditions of the rocks, their angle of bedding, and fossiliferous contents; from this he decides the best position for his borings, and while the work is proceeding he is constantly taking notes regarding each bed, its thickness and other features which may be of some use to him later on. Should his work prove successful, by striking the desired seam he has been anticipating, he can then by a careful study of the records kept form a reasonable estimate of the capital required to sink the shafts, and whether there will be much trouble with water in the different strata which the shafts will pass through. He is, therefore, able to make preparations in advance, and thus save much time which would otherwise be lost if these contingencies had not been expected. Another fine example of the use and teachings of geology is that which enabled some of our leading geologists to assert the presence of coal in Kent. The geographical and superficial nature of the county shows very little indication of the presence of coal; it was mainly this which caused the assertion to be ridiculed by many as an idle dream—but in spite of this geologists by noting the folds called anticlinals and synclinals of the strata between South Wales and the Continent still persisted in their arguments. Bore-holes were put down to test the truth of these statements, and judging from the developments taking place around Dover lately, we will admit the value of this and what it means to the promoters, and the welfare of the county generally.

In choosing the site of his shafts the mining engineer will, by the aid of his geological maps, trace the positions of faults, their direction, and how they have affected the position of the various coal seams, deciding accordingly. Neglect of these

very often makes the difference between a well laid and a badly arranged colliery; the presence of unexpected faults and other interruptions confuses and prevents the laying out of economical haulage systems, interferes with ventilation arrangements, retards the opening out of the mine, and greatly increases the cost of producing the coal. We can easily note from a section of any coalfield how the measures have been elevated and depressed by the anticlines and synclines, which has the effect of preserving our coalfields in one place and laying them open to the action of the atmosphere and other denuding agencies in others. It is mainly by this process extending over long periods of time that our coalfields have become separated. A good example of this is the distance which now separates the South Wales from the Forest of Dean coalfield. All that is now left of this part of the coalfield is a dome or inlier, which shows the Silurian formation at the surface. From this will be realised the great thickness of strata which has been swept away since the Coal Measures were laid. From denudation we are taught how the different formations have been affected by the influences that have been acting on them through the ages. The mining engineer employs this knowledge in a practical way by observing the different rock formations, and how they have been affected by the weather; he is then guarded against the risk of using a wasting and worthless building stone for the construction of his buildings. In the process of working coal many difficulties are met with in the form of slips, faults, dykes, &c. With these the seam may be elevated, depressed, or cut-out, and for the time temporarily lost. With a small geological knowledge the mining engineer can from certain evidence determine their direction—upthrow or downthrow—and be able to guide his workmen to recover the lost seam in the most expedient way. The driving of cross measure headings and even the cutting price of coal can be more easily estimated by acquaintance with some of the outlines of geology.

In the main this answer is my own composition, but I have been assisted in preparing it by the perusal of geological notes in the past issues of this Journal.

J. H. Moore, The Mills, Gelli Groes, near Newport, Mon.

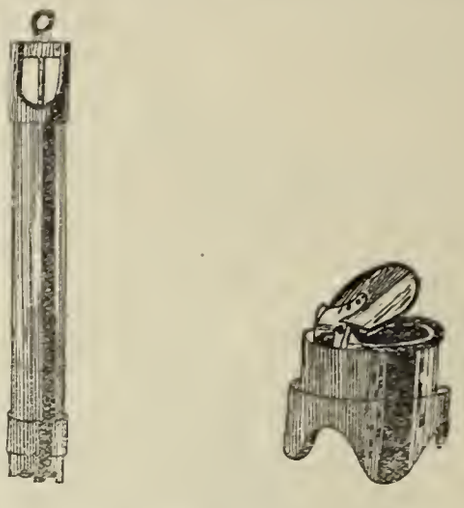
[Note.—To say that the general run of mining engineers have more than a mere smattering of geological knowledge would be to exaggerate. In a coalfield where there are no dislocations of any size the average man gets on very well in spite of this want of knowledge, but in a district where large faults exist he finds himself hopelessly at sea. It is almost impossible on finding a seam to say definitely which seam it is unless the adjoining strata above and below for a considerable distance are known, and found to correspond with the strata in connection with some other known seam. Suppose we meet with a fault of apparently large size. If we are well acquainted with the geology of the strata we may, on proving the ground for some distance on the other side of the fault, be able to say with something approaching certainty at what distance above or below we may expect to find the lost seam of coal, or if that proves to be a great distance, we may, by a simple calculation, be able to say whether or not some other seam can be met with close at hand. Of course, a fault generally gives a pretty good indication as to whether the lost seam should be sought for above or below, but seeing that at any time we may meet with a reversed fault it is necessary to examine the strata very carefully before deciding in which direction the lost coal lies. Suppose the strata met on the other side indicated that the lost coal might be found 80 yards below, but we knew that 100 yards above this coal there was another workable seam, it would probably be well worth our while to drive up 20 yards to our new seam, leaving the lost one to be worked through a deeper seam. Without some knowledge of geology a lot of money might be spent in a case like this without any profitable result. We know of one mine, where in a short space of perhaps a quarter of a mile, we can walk out of one seam into another thrown up over 100 yards on to a level with the first, and a very little further on we pass into another thrown down 20 or 30 yards. Apparently the road passing through these three seams is in one seam all the time, and without some geological knowledge mistakes in locating the other seams might easily be made.—C.C.M.]

J. Grundy, A. Nelson, D. J. Richards (*12 marks each*).
A. Stephens, E. Ambrose (*8 marks each*).

Sludger Pump.

Q. 6.—*Give a sketch of the Sludger pump, and describe its use in boring.*

A.—In Mather and Platt's method the rods are done away with, and round or flat ropes (similar to a winding rope) substituted. The tools of the second class are operated by being jerked or plucked up by the rope and dropped suddenly. The chief one is the Sludger Pump. This consists of a cylindrical shell with a ball or clack valve near the bottom. Of course, in using this ball, or clack valve, sludger as it is termed, it is necessary that there should be water in the bore-hole. The



Illustrating Question 6.

sludger is dropped suddenly into the water and *debris* which consequently gets above the valve. A sudden jerk upwards lifts the *debris*, and whilst the latter is still moving upwards the sludger is dropped down again through another layer of the *debris*. Another sudden jerk sends this up the cylinder, and after one or two further plucks the cylinder will probably be full, and may be raised to the top to be emptied. This is the most expeditious way of clearing bore-holes when it can be adopted; the time of lowering and raising the Sludger Pump with the filling is only a very few minutes.

Assisted by *Modern Mining Practice* by Bailes.

E. Ambrose, 28, Trinity Street, Rhostyllen, near Wrexham.

J. Grundy, A. Nelson, A. Stephens (*12 marks each*).
H. D. Holmes, R. Beaver (*8 marks each*).

Electricity in Mines.

Q. 7.—*What are the advantages and disadvantages of earthing electrical machines and cables underground?*

A.—Earthing electrical apparatus in mines means connecting them to the general mass of earth in such a manner as will ensure at all times an immediate discharge of electrical energy without danger. Electrical Rule 8 states that all metallic sheaths, coverings, handles, joint boxes, switch gear, frames, &c., shall be earthed by connection to an earthing system at the surface of the mine. Everything is generally earthed in parallel; it is bad practice to earth the motor frames, switches, distribution boards, &c., in series. This matter of earthing or the insulating of the neutral point as applied to a three-phase system is very important, and is, in a way, approached from diametrically opposite aspects by engineers. Each system possesses its advocates, but a consideration of local conditions is always recommended; in some cases the neutral is earthed in many places, whilst in others it is earthed in one place. Experience has dictated that a combination of these two extremes to one system of universal practice is best, *i.e.*, the neutral of a three-phase system should be earthed at one place only, and that through a suitable resistance.

Advantages of Earthing.—In the first place everything is at a certain potential, the mass of earth even has a certain potentiality, and when speaking of a current flowing to earth we understand that the source of this current is at a potential above that of the earth, but if the source of current is equivalent

to that possessed by the earth, then no difference of potential exists, and consequently no current will flow, in which case it is said to be at earth potential. If anything possesses a suitable electrical connection with the earth, the apparatus so connected is said to be "earthed." The advantages of an efficient earth come under the following heads: (1) Serious shocks are prevented. (2) Risk of fire is considerably reduced. (3) The tracing and discovery of faults on the electrical parts of the machines is facilitated. In the first case, if any leakage takes place in an earthed system, it is practically impossible for any person to receive a serious shock, as the earth wire will give the leakage current a better path to earth than a man's body. Therefore, the main object of earthing is to prevent persons from receiving a shock when a fault takes place. To ascertain what pressure is permissible to the earth system, without being of danger to persons employed in the working of such machines, various tests are carried out. In practice the greater number of shocks are received when persons are handling the apparatus, and standing upon a more or less efficient earth when the fault to earth occurred. The results of numerous tests conducted by Mr. W. Foster show that (according to his last test) the person could only stand 32 volts voluntarily, and was passing 0·3 ampere, and since the current was only applied gradually he would not have voluntarily withstood 20 volts if applied suddenly. Considering also that the skin on the arm was punctured at about 20 volts, and persons are liable to receive a shock on tender skins, such as the back of the hand or wrist, it appears advisable to keep the pressure in the earth system below 50 volts between any earthed metal work and earth.

The advantages of earthed neutral are: (1) The maximum potential to earth of any phase is limited to 58 per cent. of the line voltage. (2) The danger from shock is greatly reduced because contact with any phase and earth is only 58 per cent. of the line voltage. (3) Leakage tripping devices can be used which will switch off the supply when an earth occurs on any phase. This reduces danger of shock and explosion. (4) Leakage to earth results in isolation of a defective circuit.

The advantages of an insulated neutral are: (1) It is possible to run a system with one phase earthed. (2) Two phases must go to earth or be short-circuited before the current supply is interrupted. (3) There appears to be less electrical stress on the insulation.

Disadvantages of Earthing.—Where earthing is employed the natural tendency is to place absolute reliance upon the same, when perhaps it is faulty and not reliable. Strictly speaking, this fault lies with the persons concerned; accidents have occurred due to carelessness in this direction.

Where the neutral is not earthed, the breakdown of the insulation of one phase does not at once cause sufficient current to flow to strip the automatic switches through which the faulty conductor is fed, but a discharge takes place at the fault, which very speedily destroys the insulation of the other conductors in immediate proximity, and a very violent short-circuiting takes place. Cases are recorded in which these short-circuits were so heavy that the automatic switches through which the faulty conductor was fed opened with a loud report, frequently spilling the oil in the switch-tank, and sometimes damaging the switch.

Finally, an insulated system throughout with unarmoured cables is less expensive than armoured cables with an earthing system. This is perhaps the reason why so many such insulated installations have been installed without the mid-point being extended.

Indebted for assistance to Papers read before The Association of Mining Electrical Engineers.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

J. Grundy, A. Stephens, R. Beaver (*12 marks each*).
E. Ambrose (*8 marks*).

Ventilation.

Q. 8.—*What gases would you expect to find on opening an area that had been sealed for some considerable time owing to the presence of a gob-fire? How would you search for them, and how would you recognise them? Explain fully.*

A.—The gases I would expect to find on opening an area that had been sealed for some considerable time owing to the presence of a gob-fire would be carbon dioxide (CO_2), sulphuretted hydrogen (SH_2), carbon monoxide (CO), and carburetted hydrogen (CH_4). In searching for these gases the utmost precautions would require to be taken, and I might state at this period that I would not search for any of them until large volumes of air had traversed through the mine (I am presuming that the fire is extinguished) or the area in which such had occurred, so as to have a chance of being diluted providing the ventilating appliances were favourable. Then I might state that I am of the firm opinion that a rescue apparatus would not give bad results in searching for any of these particular gases in the initial stage, because they are as likely to be prevalent in dangerous quantities as otherwise, hence prevention is better than cure. Again we have these apparatus designed for life saving and safety, why not put them in use when at all essential? The safety-lamp test for some of these gases is not to be depended upon, especially so in the detection of CO and in CO_2. Then I would search for the presence of CH_4 by means of a safety-lamp by noting the behaviour of the same if present on the flame of the lamp. In regard to CO_2 this is not safe to search for by means of a safety-lamp, as it may be present in large quantities. G. H. Winstanley states that a lamp will continue to burn with decreasing brilliance until between 10 and 15 per cent. is present, when such will be extinguished. Difficulties with breathing begin when the proportion of CO_2 exeeeds 4 per cent. With 10 per cent. there is severe distress, and at 15 per cent. loss of consciousness is only a matter of time and the individual. Hence it would be better to err on the side of safety by adopting some other means of detection than the lamp, say such as taking a sample of air, and passing it through lime water which if CO_2 is present in the sample air turns the water milky. It is said that this gas will make a lamp burn black and smoky, or otherwise extinguish it altogether when used for its detection. This gas (CO_2) should be searched for near the floor, and CH_4 near the roof, providing diffusion is not taking place rapidly. I might state before leaving these two gases that there are many ways not only of detecting, but of accurately determining the amount of CH_4 present in mine air. For practical purposes, however, we are only concerned at this moment with a method which is applicable for the mine at any time and without specially prepared apparatus, a method which can be undertaken by a person not necessarily skilled in laboratory work, but which at the same time enables a person of reasonable intelligence to arrive at results that may be relied upon as approximately accurate. Hence the adoption of the safety-lamp placed in the hands of an experienced operator, capable of realising the necessity for care, and of appreciating the nature and purpose of the test. In regard to CO we know that it is one of the results of the imperfect combustion of substances containing carbon, probably due to an insufficient supply of air or too low a temperature of combustion, thus being produced by gob-fires. From a mining point of view its most important property is undoubtedly its effect upon human respiration, also being a highly poisonous gas and of a less specific gravity than air. The best practicable method for its detection is its effects upon respiration, especially so on warm-blooded animals such as mice. It is said that a mouse is dangerously affected when ·02 per cent. of this gas is present, being affected 20 minutes sooner than a man when there is ·5 per cent. present. Hence when searching for this gas it would not be a bad plan to be equipped or provided with a small cage containing a few mice or canaries. Apart from this test we have the blood test, which may be performed by taking a mixture of blood and water; if the solution contains 1 per cent. of normal blood it is of a pale and yellow colour, but if taken into an atmosphere containing CO and shaken up its colour changes to pink. We have also now a special detector termed Simoni's CO Dectector; its action is the colouring of paper. There are two indications with this apparatus: (1) Slight colouring of paper which is attached to the appliance; (2) when it turns black.

In regard to SH_2 no gas is more easily detected; the only apparatus necessary is the organ of smell. Even those whose sense of smell is not keenly developed will have no difficulty in detecting its presence, even in very small proportions. It is often described as possessing a smell resembling rotten eggs; as a matter of fact, "rotten eggs" owe their aroma to sulphuretted hydrogen. In quantities so small as ·08 per cent. fatal results

may follow continued breathing for an hour or more, whilst ¼ per cent. will cause death in a few minutes. Less than the latter percentage, however, is capable of producing distressing symptoms, and the greatest care should therefore be exercised in entering places where this gas is known to exist.

Jas. Grundy, 550, Wigan Road, Bryn.

[Note.—This question certainly does not require as an answer a description of the analytical method of testing a sample of mine air for the presence of the various gases met with in coal mines. We should suggest that nothing is required or permissible to be suggested in answering the question, other than the possession of an efficient safety-lamp, a keen sense of sight and smell, a canary or mouse, and possibly some lime water, together with, of course, a knowledge of the properties of various gases met with in coal mines. Probably the gas, under the circumstances mentioned, which would be the most difficult to detect would be carbon monoxide. Lamps might be burning brightly and showing no trace of any gas present, and still without warning this insidious gas might be met with in dangerous quantities. It is easy enough to detect CO_2 (carbon dioxide) because of its action on the flame of the safety-lamp and on the observer, because its action or effect on the observer is nothing like so sudden as that of carbon monoxide; but the only way to detect the presence of the latter gas in time to prevent danger to life is to carry a canary or mouse, as one of these is affected by a less percentage of the gas than is a man. People not very long ago used to laugh at this idea, but it has now gained firm ground, and nowadays the man who would rush into a mine after an explosion, or into an area affected by a gob-fire without taking one of these animals with him should not be looked upon as a hero.—C.C.M.]

E. Ambrose, A. Nelson, A. Stephens, W. A. Onley (*12 marks each*).

Electricity Rules.

Q. 9.—*What precautions require to be taken when electric cables are put in a shaft?*

A.—General Rule 5, Section 3, of the Special Rules for the Use of Electricity, says: All cables used in shafts must be highly insulated and substantially fixed. Shaft cables not capable of supporting their own weight shall be properly supported at intervals varying according to their weight. When the cables are not completely boxed in and protected from falling material, space shall be left between them and the side of the shaft that they may yield, and so lessen a blow given by falling material.

The following important points should be kept in view:—

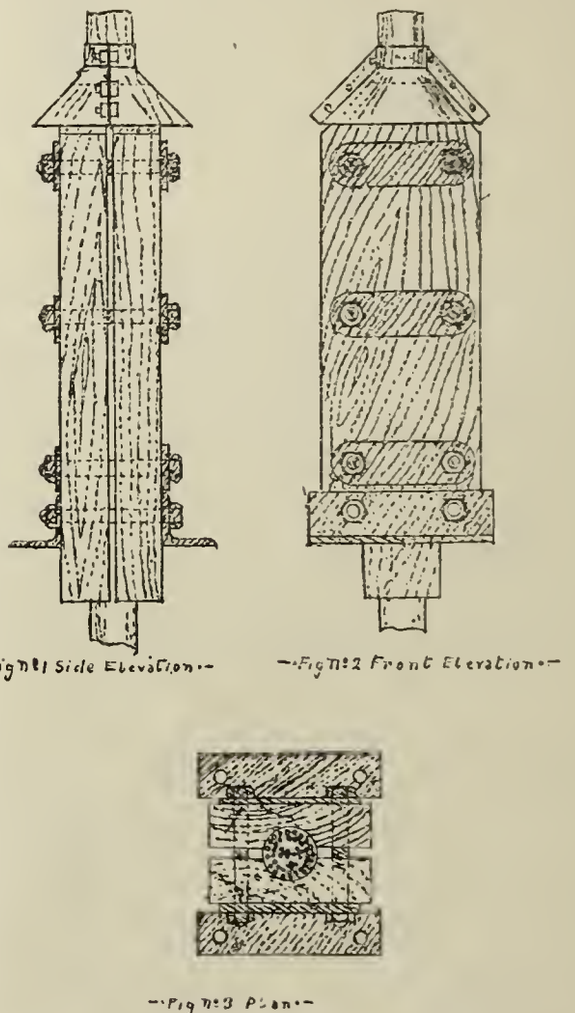
1.—The cable should be so fixed in the shaft that it is not unduly exposed to mechanical damage by the moving cages or from anything falling down the shaft.

2.—If the shaft is at all wet the cable must not be fixed in such a manner that it becomes a natural means of conducting the water, that is to say, there is always a more or less continuous stream of water running down the cable. Indeed, in a wet shaft special precautions must be taken to preserve and protect the cables.

3.—The cables should neither be allowed to carry any considerable amount of their own weight nor undue strain or tension. In many cases armoured cables are allowed to support their own weight. It is claimed that the cable "gives" in the event of anything striking it, but it should be remembered that an armoured cable is built up of several different kinds of material, steel wire, copper wire, and insulating material possibly of more than one kind. Now, all these materials possess not only different degrees of strength to resist tension, but also different degrees of elasticity, and when a long length of cable is allowed to support its own weight it is obvious that the stretching tendency towards the top end must to some extent disarrange the various materials, and sooner or later water or dampness will find its way into the cable, and the insulation will more or less rapidly break down.

4.—The cables once fixed should be periodically examined. Accumulations of dirt and *debris*, "as a rule wet," should be removed from the tops of the cleats, where they would tend to set up corrosion, and the whole lengths of the cable and supports should be regularly treated to a coat of Stockholm tar.

As an instance I might give the method of supporting a three-core solid filled bitumen cable, doubly armoured, working at 2,200 volts, each core consisting of 19 wires of No. 14 S.W.G. It is supported by cleats fixed every ten yards, each cleat being fitted with a semi-circular groove, which, on the two halves being put together, grips the cable securely, but without any tendency to distort or damage it. The cleats are 2 feet 6 inches long (for this particular cable), 2½ inches thick, and 8½ inches wide. It will be seen in *Figure 1* that the groove formed in each part is not a complete semi-circle, so that when the two halves are fitted together with the cable between them they do not actually meet; there is a space of ¼ of an inch when they are bolted up to grip the cable. For the latter purpose half a dozen ¾ inch bolts are used, with strips of iron 2½ inches wide by $\frac{5}{16}$ inch thick, to prevent splitting the timber. *Figures 1, 2* and *3* show how the bottom of the cleat is finished off so that it may rest upon and be secured to the beams or buntons in the shaft. About 3 inches from the bottom of the timber cleats two short pieces of 2¾-inch × 2¾-inch angle irons are secured with a couple of ⅝-inch bolts, forming a good foot to rest



Illustrating Question 9.

on the beams. The timber is also cut down as shown in sketch to form shoulders flush with the lower surface of the angle irons, thus making a perfectly sound footing for each cleat. Attention may be called to the sheet iron bonnet fitted to the top of each cleat. This bonnet is in two halves. A strip of brattice cloth is lapped round the cable just above the cleat, the bonnet fitted and secured in the manner shown, the object being to prevent wet dirt and *debris* from accumulating on what would otherwise be the flat shoulder formed by the top of the cleat, a source of possible corrosion and damage. During the actual operation of placing the cable in the shaft the best plan is to fix a cable drum in the cage if there is room, or mounted

under the cage so that it can involve a simple form of brake being contrived to check its rotation. The cage is then slowly and intermittently lowered, paying out the cable as it descends, and which is secured to the cleats at the proper intervals. In this way the cable can be fixed without incurring any damage through permitting it to hang in the shaft, or carry any considerable amount of its own weight.

When the shaft is too deep for the cable to be put in in one continuous length, the necessary joint must be made by means of a suitable joint box, the best plan being to carry the ends a short distance into a mouthing to a proper joint box, this being much better than a straight through joint box in the shaft itself.

Indebted to instruction by Mr. G. H. WINSTANLEY.

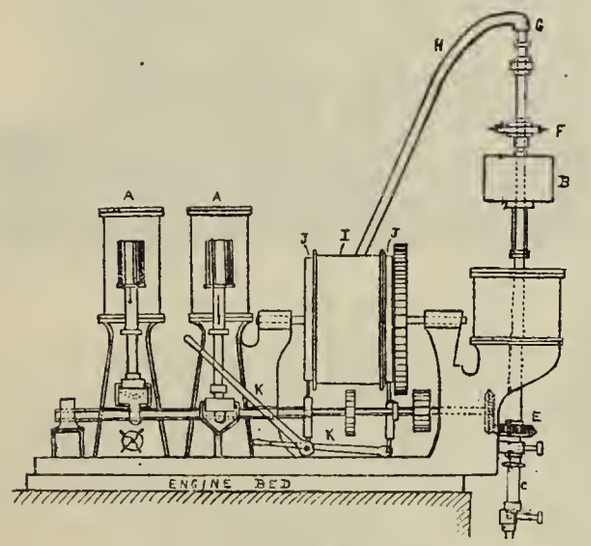
FRED HUTCHINSON, 27, Longfield Road, St. Helens Road, Bolton.

W. Heys, W. T. Hughes (*12 marks each*).
J. A. Withington, G. Addison (*8 marks each*).

Boring.

Q. 10.—*Describe the operation of boring for coal by a method giving solid cores of the strata passed through.*

A.—Various types of boring apparatus are used when boring for coal, several of which are designed to give solid cores. Solid cores may be obtained by using either the percussive or rotary type of boring apparatus, the following methods of boring each giving cores: Percussive Method—Mather and Platt's, Kind's, Fauck's, Frich's Hydraulic Borer, and the Keystone Core Drill. Rotary Method—Diamond System, Davis-Calyx, and Cyclone Drill.



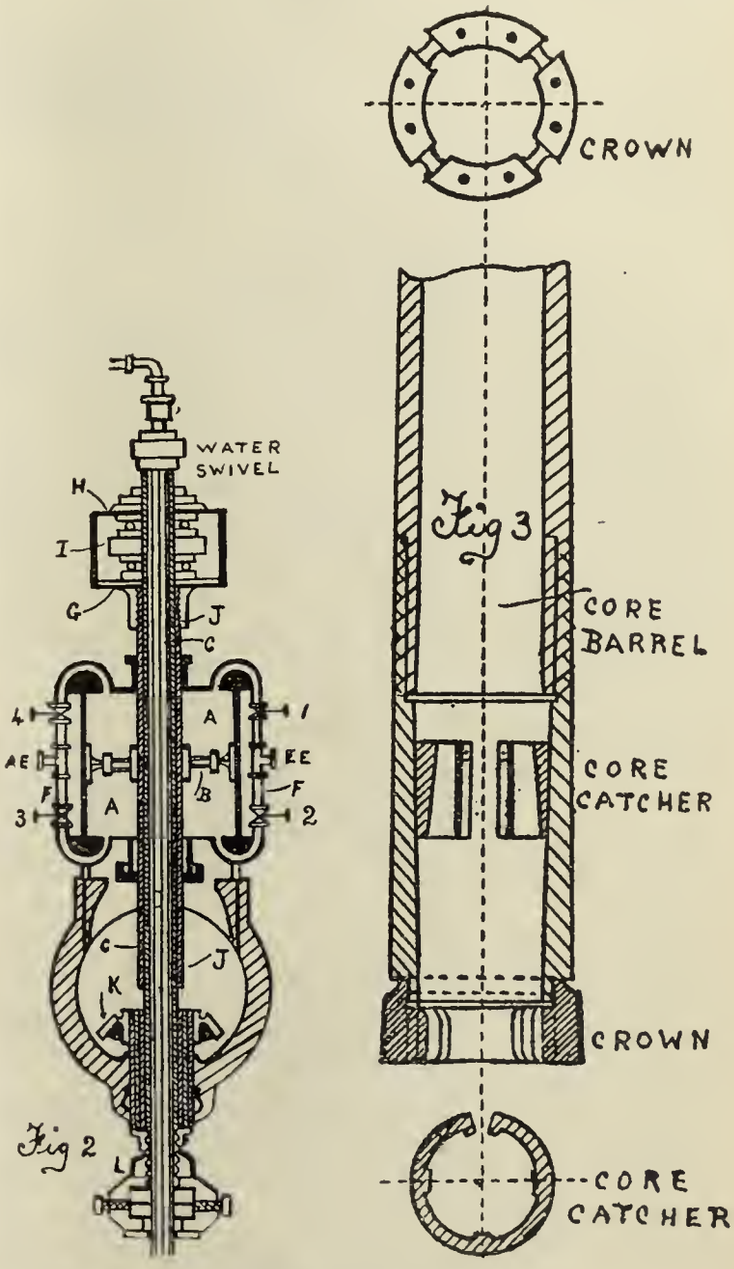
Illustrating Question 10.

The rotary system of boring is generally acknowledged to be the best for the purpose of proving minerals, and by far the greater percentage of bore-holes put down for this purpose in recent years have been bored by means of this system. The great advantages that rotary boring processes possess over the percussive methods are that the crown being continually applied in cutting, the driving force is more economically utilised than in boring by percussion, and (undoubtedly the chief advantage) when penetrating compact strata the rotary systems provide, as cores, very complete sections of the rocks penetrated, these cores being far superior, both in respect to the proportion of rock obtained, and as to continuity of operation to those which the annular trepan gives in the percussive methods.

Sullivan Diamond Core-Drill.—The great advantage this drill possesses over others is that it drills a smooth hole in a vertical or inclined direction, and provides, at the same time, a more or less complete section, as a core of the strata penetrated. Undoubtedly, seeing that its minimum capacity is 3,000 feet, it may be considered to be one of the premier boring appliances in use at the present day. The hydraulic apparatus is a special feature, and by means of this apparatus the feed may be increased, diminished, or reversed, while the drill is running. All shock, such as would occur, for instance, were a cavity struck, is prevented.

Rotary boring apparatus are composed of three principal parts: (1) The driving gear, (2) the boring rods, (3) the drilling apparatus. The driving gear is shown in *Figure 1*, and must be firmly secured to its bed. *AA* are steam cylinders; *B* hydraulic feed; *C* drill rod; *D* chock: *E* bevel wheel attached to drive rod; *F* thrust box; *G* water swivel; *H* hose; *I* drum of hoist; *JJ* brake straps: *K* lever working brake straps.

In this type of driving gear the advance or feed of the rods is secured through the medium of a single cylinder hydraulic piston, the action of which is made clear by the sectional sketch, *Figure 2*. In this, *A* is a hydraulic cylinder, in which moves the piston *B*, attached to the piston rod *C*; *EE* represents a tee by which connection is made to a circulating pump;



Illustrating Question 10.

AE on the left-hand side is the water escape, the water being let in and out through ports and the brass tubes *F*. Valves *1* and *2* are the inlet valves, *3* and *4* being outlet valves. When valves *1* and *3* are open, *2* and *4* being closed, water is pumped in above the piston and escapes from below it, so the piston will move downward; when valves *2* and *4* are open and *1* and *3* closed, the reverse is the case. By closing valve *3* the feed is instantly stopped. *G* is the thrust plate to which the upper end of the piston rod is screwed, *H* being another thrust plate connected to the former by means of studs. Between these plates, on each side of the collar, are two sets of friction-

ball roller bearings *I* of the drive rod *J*. It is through this collar that the vertical motion of the hydraulic piston is transmitted to the drilling bit. The rod *J* is driven by mitre gear *K*. The boring rods pass up through the drive rod to which they are clamped by the chuck *L* screwed into the bottom of the drive rod. The rotating drive rod moves freely through the mitre gear, the feathers of the latter sliding in grooves in the former. Pressure gauges on the supply and discharge pipes indicate the variations in the pressure on the bit, so enabling the boring superintendent to determine when the drill passes from stratum to stratum of varying degrees of hardness.

Boring Rods and Drilling Apparatus.—The boring rods usually employed are about 5 to 10 feet in length, made of either iron or steel, of hollow section, with tapered screwed ends and couplings which enable expeditious connection and disconnection to be made. The boring rods are screwed on to the sediment tube. To the lower extremity of the boring column is fixed the core-barrel and the core-catcher, terminating in the bit or boring crown. The boring crown is studded with Borz diamonds. A current of water forced down through the hollow rods washes away the sediment and keeps the diamonds cool, which, as the crown is usually rotated at a rate of from 90 to 125 revolutions per minute, and sometimes as high as 250 revolutions per minute, is very necessary. At intervals, usually after drilling 10 feet, the rods are withdrawn by means of the hoisting winch, and the core extracted from the core barrel. The circulation of the water through the crown is facilitated by a number of grooves channelled in the interior as well as the exterior surface. The crown, which is always only a few inches in height, is screwed into the core barrel, of which the exterior diameter is slightly less than that of the crown, in order to facilitate the passage of the water current and the sediment, and its length is generally from 20 to 30 feet, though it is seldom possible to continuously bore this depth. It is given this length in order that it may serve as a guide to the borer, and assure the rectitude of the hole. The number of diamonds in the crown varies with the size of the crown, there usually being six in the 2-inch diameter crowns, eight diamonds in sizes of 3, 4, and 5 inches, whereas from ten to twelve are used in 7-inch crowns. The rods, coupled to the sediment tube, core box and crown-piece extend to the bottom of the hole. These are rotated by the bevel wheel *E*, the diamonds acting by attrition wear away or cut an annular groove in the strata, so forming a central core over which the hollow boring rods pass as the boring proceeds. During this operation a current of water is being constantly forced down to the boring crown, carrying away the *debris*, and the force of the water may be increased or diminished at will. The water after being forced down to the crown returns to the surface, whilst the *debris* carried in suspension falls back into the sediment tube. As the boring proceeds, rods are being continually added so as to keep the crown to its work. When the run is complete the rods, &c., are withdrawn by means of the hoisting engine, and the first lift of a fraction of an inch brings the core-lifter into action. The core-lifter (*Figure 3*) grips the core near to the bottom, breaking it off, and bringing it to the surface when the rods are raised, where it is examined, labelled, and carefully placed on one side. The sediment is emptied out of the sediment tube, when the whole boring apparatus are lowered into the hole, and added piece-meal until the bottom is reached, when boring again commences.

The speed of boring depends upon the number of revolutions per minute of the boring crown, nature of strata being bored through, &c. The cost of boring also varies, but generally speaking it is 8s. to 10s. for the first hundred feet, 15s. to 20s. for the second hundred feet, 20s. to 25s. for the third hundred feet, &c. For deep and important bore-holes special contracts are made.

Indebted for part of this answer to *Modern Practice in Mining* by R. A. S. Redmayne, H.M.I.M.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

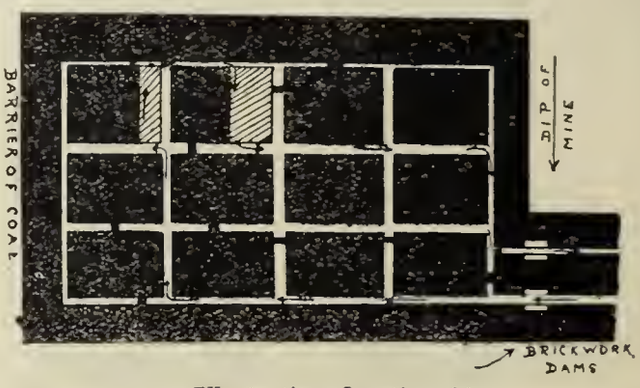
F. Hutchinson, J. Taylor, J. A. Withington, W. T. Hughes (*12 marks each*).

Methods of Working.

Q. 11.—*How would you work a seam which is subject to spontaneous combustion so as to secure the maximum safety?*

A.—The liability of any seam of coal to the occurrence of fires arising from spontaneous combustion needs careful consideration when selecting an efficient method of working. To say the least, gob-fires are always a menace to the mining industry, bringing in their train danger, anxiety and expense. Many methods of working are applied to such seams, but in most cases other conditions are taken into consideration. The method of working adopted should be such that the fire can be adequately dealt with, preferably without interfering to a large extent with the output. The seam may be worked by the long wall retreating method, but neglecting other conditions the only rational method of working applicable to a seam of this description is some modification of the pillar and stall system (panel system) or a method of square working. With these systems the mine may be said to be worked by a number of small districts or panels, an efficient solid barrier of coal being left between each panel. Usually each panel has its own separate intake and return, consequently, if a fire breaks out in one panel it can easily be isolated from the other workings. This would have little or no effect upon the output, as the other panels can be kept working.

In the panel working, as shown in sketch (adopted in North Staffordshire), the panels are worked from the rise to the dip. After the narrow roads have been driven, cutting the coal into pillars, the rise pillars are then robbed and the gas escaping from the coal ascends into the goaf. As each row of pillars is robbed stoppings are put in to prevent the circulation of air through the new goaf; the next lower level being the return, but the goaf is swept by a sluggish ventilation. To prevent



Illustrating Question 11.

gob-fires a good current of air should be made to circulate round the edges of the goaf. In this panel method the working edge of the goaf is always in touch with the air-current whilst the pillars are being removed. The chief advantages of the panel method are: Small panels of coal are opened out, and they can be quickly finished. Should a fire take place during the extraction of the pillars the two entrances to the panel can easily be dammed off. When a panel is sealed off there is little or no effect upon the output.

As shown in sketch, suitable sites are carefully prepared in each road for dams. The site chosen should be in solid strata, *i.e.*, free from cracks, breaks, or fissures, &c., the brickwork being prepared with good cement.

When a fire is detected and found to require sealing off, it is obvious that the fire may increase in intensity before the dams can be built, and the fire sealed off. As a preliminary precaution I should have a brick framework built, as shown in sketch, suitable for hanging an iron door 1 inch in thickness thereon. These doors form a sufficiently air-tight joint, and may be used advantageously whilst the dam is being built. When a door of this description is available, immediately a fire breaks out or is detected the men are withdrawn and the iron door closed. I should preferably use sliding doors or doors to open against the air-current, and also keep a good supply of sand at this spot ready for immediate use. Gob-fires are caused or initiated by the presence of combustible material in the goaf, such as rubbish and small coal, broken timber, old brattieing, &c. Precautions should be taken to keep the goaf as clear from combustible material as is practicable.

All matter subject to oxidation should be removed from the mine or gobbed in air-tight compartments, or in some favourable place, as, for instance, in dip workings, which can be filled

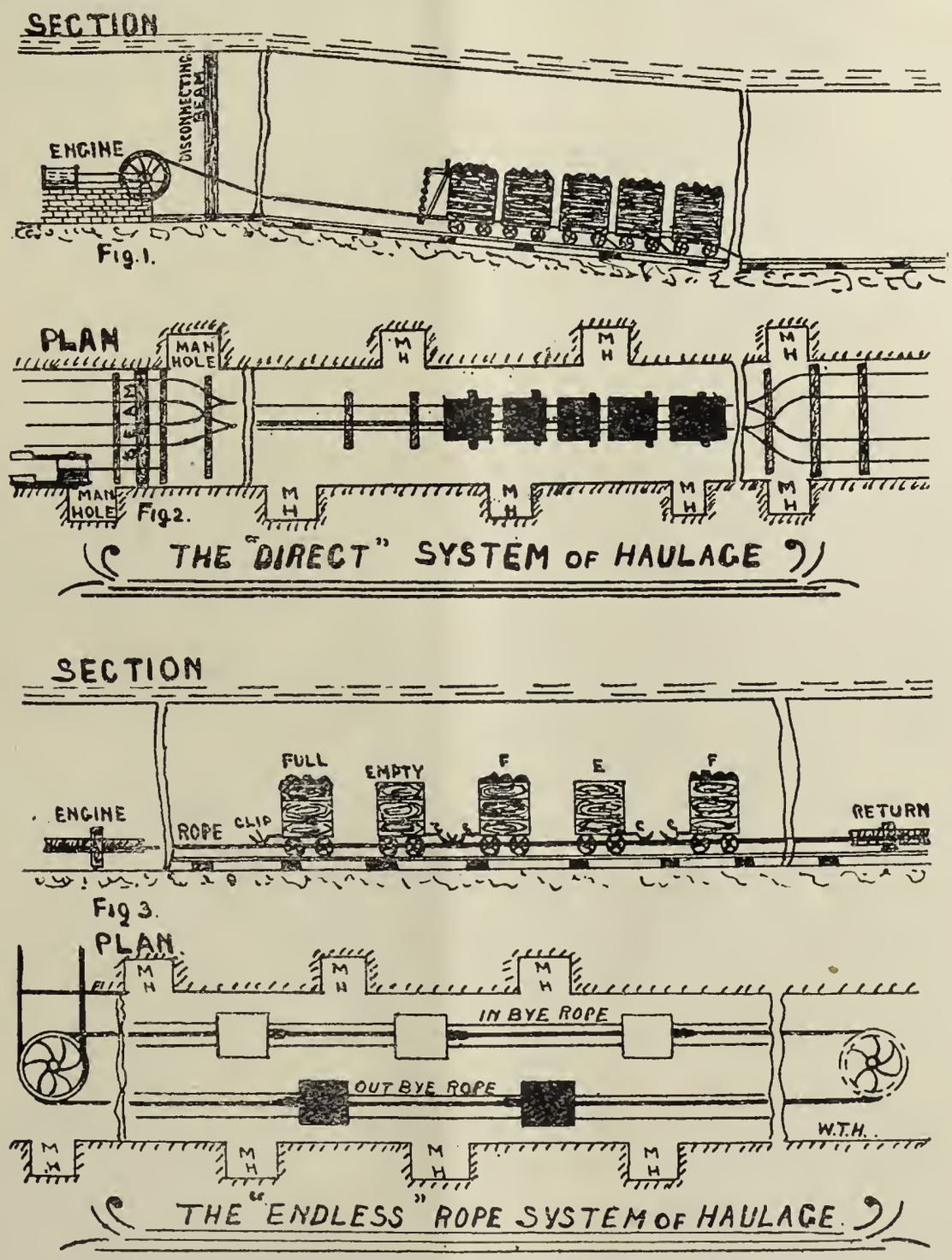
with water or carbonic acid gas. When coal dust is heaped up on the main haulage (intake) road, and should any obstruction be placed in the road accidentally, such as a tub or a fall of roof, just opposite the heap the air is impinged and the coal dust, though on a main intake road, is very liable to spontaneous combustion and ignition in a very short time, fires having occurred through this in a night.

In many cases owing to the carbonaceous nature of the roof it is impracticable to exclude matter subject to oxidation, from the goaf. Air should in this case be rigidly excluded from the goaf. The ordinary pack walls are inadequate for this purpose, as air leaks through them. By the use of the wax-walling method the leakage could be reduced to a minimum. Although costly, they are to be recommended in any seam of this description, save perhaps for very thick seams. The wax wall may consist of a longitudinal wall, or a series of transverse packs constructed of lumps of well-tempered clay about 1 foot thick, built into the main packs. Sand and flue-dust are often used as substitutes.

Should sweating or fire-stink be observed a longitudinal sand pack is run alongside the gate, thus keeping the air from pulling through to the place where the fire is expected to be.

In places where the above methods have failed it is very likely that the goaves have not been completely sealed off, and that air has been allowed to pass into the goaf. The working faces should be pushed as rapidly as possible, so that heaps of slack are not exposed for any length of time to the air-current. In times when trade is slack, or a strike takes place, a wax-wall should be run along the face of the goaf forming closed compartments.

The workings should be frequently inspected by persons conversant with the detection of gob-fires, having with them at each inspection a small thermometer so as to detect any increase in the temperature of the return or mine workings. Where the shafts have been sunk to the dip side of the seam, gob-fires would be eliminated owing to the coal being worked to the rise and allowing the goaf to fill with water.



Illustrating Question 12.

All materials should be kept ready and in an easily accessible position, so that when a fire occurs the work of extinction can be immediately commenced.

Indebted for assistance to a paper on Gob-Fires, Methods of Prevention, and Extinction, by A. H. Bonner.

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F. Hutchinson, G. Addison, J. A. Withington, W. Silverwood, G. A. Hyde, W. T. Hughes (*12 marks each*).

Haulage.

Q. 12.—*Describe two arrangements of haulage, and say under what conditions they are suitable respectively.*

A.—The two systems of haulage I propose to deal with in my answer are "The direct system of haulage" and "The endless rope system of haulage."

The first system may be described as one bearing at least three names, *i.e.*, direct haulage, main haulage, or single rope haulage. It can be applied to an incline free from undulations. At the top of the incline, or in a convenient position, an engine is fixed, or pair of engines, driven either by electric or other motive power, and the drum on which the rope runs is fixed to the engine. A pair of engines with cranks upon the drum shaft, or which drive it by means of a pinion and spur wheels, is a common form of the power employed. They are large enough with some reserve to do the work required of them. The rope is fixed to the drum at one end, and to the other end a connecting arrangement for attaching to the tubs. A code of signals is employed, and upon the signal being given from the bottom of the incline the full set of tubs is hauled up to the top of the incline, thence by various means to the shaft bottom, and then to the surface. After the full set of tubs has been taken off the rope at the top of the incline, the empty set is then attached, the drum is thrown out of gear, and the empty set by its own gravity descends to the bottom of incline, or towards the workings, or intermediate stations, the speed of the set being controlled by the brake under the care of the engineman. Upon the incline only one set of rails is required, but at the top, intermediate stations, and the bottom, two sets are required to facilitate the exchanging of loads and hooking arrangements. A series of roller pulleys is fixed in the middle of the road in the incline for the rope to run on, and so reduce the friction and wear. The incline is fitted with all the necessary refuge holes, stop blocks, signalling appliances, and other equipment, as required by the C.M.R.A.

It is a system which can be applied to an incline free from undulations, having a dip of 1 in 30, but if the incline is of an undulating character, 1 in 28 would be necessary for successful work. It can only be employed where the gradient is in favour of the empty set. This is absolutely necessary for the successful working of the system of "direct haulage," which is the complete return of the empty tubs to the bottom of the incline without mechanical assistance, the weight of the tubs assisted by gravitation being the only "power" to ensure their descent, pull the rope after them, and overcome the friction generated by the trailing of the rope. It is perhaps a very suitable system for drawing from dip workings, but in spite of all precautions to ensure freedom from friction, this system has the great disadvantage of attaining its limit by the weight of the rope and a certain amount of friction which is inevitable. The tubs may be equipped with "forks" or back-stays to prevent runaways.

A plan and section of this system are shown in *Figures 1* and *2*.

The "endless" rope system of haulage is one that may be adapted for all classes of work, where existing conditions and circumstances will permit its adoption. The engine may be placed at the surface, or in any convenient position underground, and may be worked with electricity, steam, or compressed air. A good power is that of electricity, transmitted from the generating station by means of cables (protected suitably) to a motor placed underground. This dispenses with the rope hanging in the shaft. No drum is necessary. We have an endless rope passing round a driving pulley at the out-bye end or on the surface, passing along the main roads to the working places; then it passes round a tightening sheave or pulley, and back again to the driving wheel along the same roadway, thus having formed a complete circuit. The rope may either run under the tubs or over the tubs. Much is to be said in favour of the under rope method. The tubs or boxes are fastened to the rope by means of special clips or hooks, or by means of chains, and are put on at regular intervals, the outgoing rope drawing the full tubs, and the ingoing rope taking the empty tubs. The tubs may either be put on in sets of two or four tubs, or if the gradient is very high single tubs are hooked on. The supply by this system of haulage is very regular and constant, thereby warranting a slower speed, so that the wear and tear of the roadways is not the same. Its great drawback is that two sets of rails have to be maintained throughout the system, although the ventilation of the mine is facilitated by the larger road necessary. This system achieves safety, economy, durability, efficiency, and requires less supervision.

The system is fitted with the necessary manholes, &c., as required by the C.M.R.A.

A plan and section of this system are shown in *Figures 3* and *4*.

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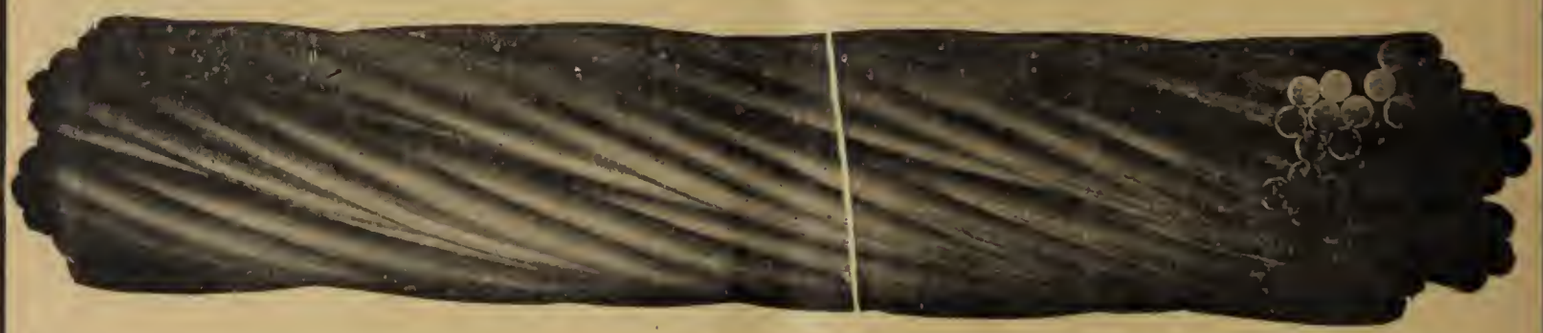

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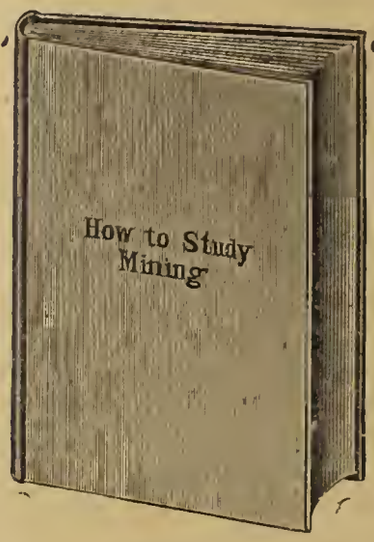

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VOL. XXII.—No. 23.] SATURDAY, JUNE 22, 1912. [PRICE 3d.

NEWS AND NOTES.

United Kingdom Coal Shipments.

A White Paper has been issued giving in tabular form a complete account of the coal carried by sea from each port of the United Kingdom for the years 1910 and 1911. The tables show that the quantity of coal exported last year totalled 64,599,266 tons, as compared with 62,085,476 tons the previous year, an increase of 2,513,790 tons. The amount of bunker coal shipped for use on foreign voyages last year was 19,264,189 tons, against 19,525,735 tons the previous year, whilst the shipments coastwise reached 22,005,021 tons, against 21,676,715 tons the previous year.

Examination Results.

The following is a list, communicated by the Home Office, of the successful candidates at the examination held in the Scotland District on the 2nd and 3rd May, 1912, to whom Certificates of Competency as Managers or Under-Managers of Mines have been granted under the C.M.R. Act, 1887:—

First Class (*Managers*): Robert Allan, Andrew Baird, William Barr, John Barrowman, David Bissett, William Black, Robert Bowman, Henry Hugh Whitelock Boyes, Gled Albert Llewelyn Brayne, William Charles Bridgwood, Andrew Brown, Robert Watt Burnie, Matthew Clark, Robert Clark, William Clark, Andrew Mitchell Cunningham, Alexander Dewar, John Bell Reggie Fleming, Frank Forsyth, Albert Ernest Fowler, John Gavin, John George, John Todd Glen, Andrew Hall, David Holmes, Charles Houston, Gavin Wardrop Howieson, George Johnstone, Charles Wood Kilpatriek, John Auld Kilpatrick, Andrew Lawson, William John Leck, Henry Norman Liddell, Hugh Logan, Thomas McConnell, James Macdonald, Neil Macallum, Walton McGill, George McMurdo, Ralph Maughan, John Nagle, Thomas Ramsay Ness, Matthew Pattinson, Hugh Penman, William Rawstron, Alexander James Ritchie, Junr., Alexander Malcolm Ritchie, Thomas Roberts, Stephen Morris Salmond, James Storie Saunders, Charles Brown Scott, James Shanks, James Sharp, James Smillie, Aister Kinnear Smith, Alan Stein, Edward Ward Stephenson, Alexander Thomson, David Trousdale, Gerald Sadler Walker, Robert Williams, John Russell Wilson, and William Wilson.

Second Class (*Under-Managers*): James Black Allan, William Balfour, Thomas Bernard, James Brown (Cardenden), James Brown (Musselburgh), Harry Armstrong Campbell, Henry Cargill, John Clancy, James Clelland, William Collins, William Colquhoun, Stewart Cuthbertson, David Davidson, James Dawson, George Dewar, Alexander Dougall, Samuel Ewart, Robert Fell, Septimus Ferrell, Alexander Fleming, Robert Ferguson, James Fleming, David Forbes, Robert Watson Frame, Alexander Glasgow, Alexander Goldie, David Ralston Graham, James Henderson, Peter Henderson, William Hendrie, James Sheddon Hogg, Thomas Jones, Walter Lumsden, Thomas McCue, James McClurg, James McKinlay, Harry McLean, Robert John McMillen, John Smith Mathieson, William Maxwell, Joseph Millar, George Wallace Miller, David Nicholson, Robert Burns Pate, Andrew Paterson, George Wright Penman, James Penman, Robert Prentice, Robert Pritchard, William Ross, Andrew Scott, David Scott, Richard Scott, Junr., John Seath, David Shimmins, George Smellie, Thomas Smith, John Spence, William Starford, Robert Stewart, David Bennie Strachan, James Tennant, Hugh Turney, Alexander Gillies Wilson.

Doncaster's Coalfield.

The cutting of the first sod of Rossington Colliery, preparatory to sinking, marked another phase in the development of the coalfield around Doncaster. Five of the collieries sunk in recent years are now being worked; four more are in process of sinking, and at least half a dozen more are projected. Lord Aberconway stated that in a few years the new pits in South Yorkshire would represent an increase in the coal output of 12,000,000 tons yearly. How was it to be disposed of? The answer was to be found in the Board of Trade returns, which showed that the demand from Europe for British coal was increasing yearly. He believed the demand from abroad for British coal would keep pace with the increased output.

State Coal Mining in Saxony.

The Saxon Government has acquired an option over a number of coalfields in the kingdom, mostly in the vicinity of Leipzig, the aggregate purchase price for the properties amounting to M. 54,200,000. The Saxon Diet has now been requested to grant this sum for the definite acquisition of the fields by the State, together with M. 2,500,000 for further exploration of the coal measures in the Erzgebirge. The main reason advanced by the Government for its action is that in 1910 only 30 per cent. of the coal required for home consumption had been supplied by the coal mines of the kingdom, and that, in order to meet the constantly growing needs of the national industries on more favourable terms, the energetic expansion of the coal production by the State is urgently required.

X-Rays and Coal.

At the recent meeting of the North of England Institute of Mining and Mechanical Engineers an interesting paper by Dr. F. C. Garrett and Mr. R. C. Burton, of Armstrong College, was read, the subject being "The Use of X-Rays in the Examination of Coal." Dr. Garrett explained that shortly after Rontgen's discovery, it was suggested that the rays might be utilised for determining the amount of inorganic matter contained in a coal, it being thought that the opacity would be directly proportional to the ash content of the sample. The inorganic minerals commonly associated with coal, however, differ so greatly in their permeability that it was very soon found that the opacity depended on the nature as well as on the amount of mineral matter, and the method proved to be of no practical value. Although the X-rays could not tell the amount of ash which a sample of coal would yield, it was thought that they would probably reveal its distribution in the coal, and might throw some light on the structure of the coal itself. The radiographs proved that this method of examination would show whether a coal with a high percentage of ash was suitable for washing, and the method would probably be found to have a certain commercial value. The study of a number of radiographs lead the writers of the paper to the conclusion that, although the true coal substance is almost transparent to X-rays, there are small, yet noticeable, differences between different coals, and even in different parts of a small specimen, and to hope that a full investigation of these may throw some light on the structure, and perhaps on the origin of, different coals. Coal from the Victoria Seam, County Durham, which was under examination, showed a curious columnar structure, and broke very easily into columnar fragments. The Victoria seam yields a famous coke, and, said Dr. Garrett, "it in interesting that such a structure as this can be detected, though in a less degree, in other coking coals examined. The number of samples examined is too small to justify dogmatism, but it seems almost as if this structure were characteristic of coking coals."

COLLIERY ENGINEERING.

By CLANSMAN.

Graphic Methods (continued).

Graphs.—Any equation may be represented by a graph or curve drawn to scale. The curve may be straight or bent, depending on the relation which exists between the component parts of the equation. If two quantities are so related that an alteration in one produces a corresponding change in the other, the relation between them may be represented in the following way, viz.: Take a sheet of squared paper. Squared paper is really scaled paper, and it, therefore, simplifies the work of drawing to scale. Draw a horizontal line across the middle of the sheet, and also a vertical line. This horizontal line we call the x-axis, and the other we call the y-axis. The point where they intersect is called the origin. On the y-axis mark off the various values of one of the quantities, and on

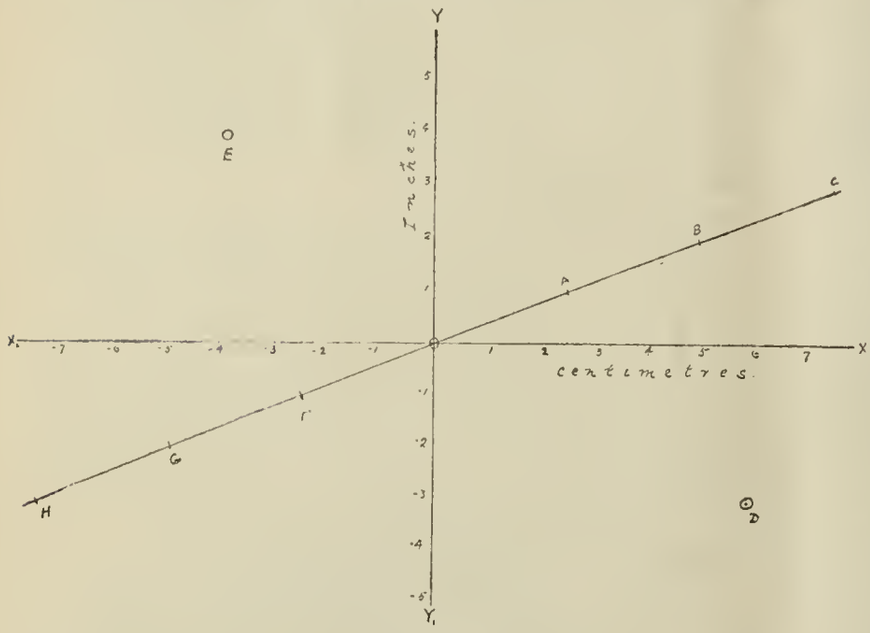

Figure 15.

the x-axis the corresponding values of the other quantity, making the origin zero in both cases. If now horizontal lines be drawn through the values on the y-axis, and vertical lines

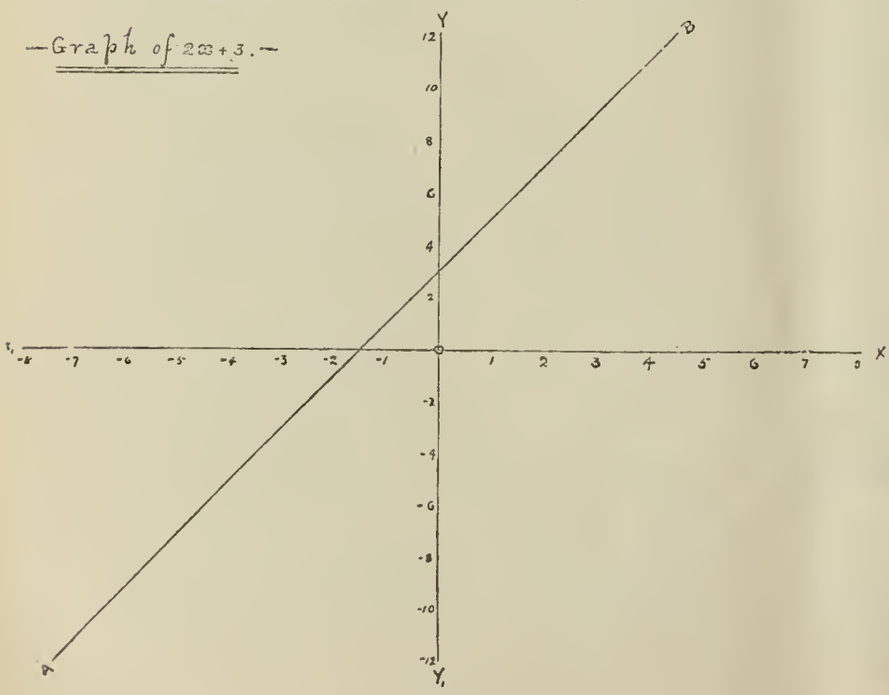

Figure 16.

be drawn through the corresponding values on the x-axis, each set of lines will meet at a point. In this way a series of points will be obtained, and if a curve be drawn through these points the relation that the one variable quantity bears to the other may be ascertained by inspection. A few examples will illustrate this.

Figure 15 is a graph showing the relation between lengths expressed in inch units and lengths expressed in centimetre units. To draw the curve we first find the values of a few convenient lengths in inches, and also in centimetres.

1 inch = 2·54 centimetres, 2 inches = 5·08 cm., 3 inches = 7·62 cm., 4 inches = 9·16 cm., and so on. These values give us four points in the curve, and they are quite sufficient to enable us to obtain the corresponding value for any length. We proceed thus: Draw a horizontal line $X_1\ X$ (*Figure 15*), and a vertical line $Y_1\ Y$, intersecting it at O. On OY mark off the length in inches, and on OX mark off their equivalent values in centimetres. The horizontal line $X_1\ X$ is the zero line of the vertical scale. The fifth line above this is marked *1*, and represents to scale a length of one inch above $X_1\ X$. Each horizontal line is, therefore, ·2 inch apart.

The vertical line $Y_1\ Y$ is the zero line of the horizontal scale. The fifth line to the right is marked *1*, and represents to scale a length of one centimetre to the right of $Y_1\ Y$. Each vertical line is, therefore, ·2 centimetre apart. To obtain the first point in our curve move along the horizontal line marked 1 inch until you come to the vertical line marked 2·54 centimetres. It is marked A in sketch. Similarly obtain the points B and C. If a thread be stretched across these three points they will be found to lie in a straight line. OC is the graph required. The reader will note that having drawn the graph he has a ready means of converting any length expressed in inches into length in centimetres and *vice versa* by simply looking at the graph. For example, a length of 2·6 inches is equivalent to a length of 6·6 centimetres, for the horizontal line marked 2·6 meets the graph at the vertical line 6·6.

In the same way one may convert square inches to square millimetres, pounds to kilograms, and so on.

Any point in a graph is determined by its distance from the x-axis and the y-axis measured at right angles. These distances are called the co-ordinates of the point. The horizontal distance is called the *abscissa*, and the vertical distance the *ordinate*. Positive numbers are marked off in the direction OY and OX. Negative values are marked off in the direction OY_1 and OX_1. The x-axis is, therefore, capable of taking all values between minus infinity and plus infinity, so also is the y-axis. Note that points in the space YOX have their co-ordinates positive; in the space YOX_1, abscissæ negative, ordinates positive; in the space Y_1OX_1, both co-ordinates negative; and in the space Y_1OX abscissæ positive, ordinates negative.

Thus the point C is point (+ 7·62 + 3), the point E is point (— 4 + 4), the point G is point (— 5·08 — 2), and the point D is point (+ 6 — 3). Points in a graph may lie in all four spaces, or in only one or two of them, depending on the values given to the variable and the nature of the equation.

When the ratio of the Y values to the X values is constant the curve is always a straight line.

Equation of a Graph.—The equation of this line will, therefore, be $\frac{y}{x} = \text{constant} = m$.

Or $y = mx$, provided the line passes through the origin. If not, the line will either pass above or below the origin, and if we take $\pm c$ to represent this distance then the equation becomes $y = mx \pm c$.

The values of m and c can be obtained by putting in corresponding values of x and y.

Thus in *Figure 15*. When $y = 1$, $x = 2{\cdot}54$, and the line passes through the origin. Therefore, $c = o$, and in $y = mx$, $1 = m \times 2{\cdot}54$. $\therefore\ m = \frac{1}{2{\cdot}54} = {\cdot}39$.

Hence $y = {\cdot}39x$, y in this case being inches, and x centimetres.

The engineer makes use of the graph for a great variety of purposes. He may plot a graph showing the relation between his wages and his expenditure: the variations in atmospheric pressure from day to day as represented by the rise and fall of the barometer; the range of temperatures or the rainfall: the variation in resistance to the passage of air through a mine, as represented by fluctuations of the water-gauge required to pass a certain fixed quantity; the law of any machine he may

have under his charge with respect to velocity ratio, mechanical advantage, and efficiency.

If he observes that two quantities vary dependently on each other, he simply plots them on squared paper as indicated above, and determines the *equation or law* connecting the two. In this way he can tell, by the equation, other values of either quantity without having further recourse to experiment.

The reader should take some well-known equations, and plot their graphs. He will find the work both interesting and instructive. The following examples may assist him :—

Plot the graph of $2x + 3$.

Taking the equation $y = 2x + 3$, proceed to find values of y for several values of x.

1	Thus when x is	−5	−4	−3	−2	−1	+1	+2	3	4	5
2	the value of y is	−7	−5	−3	−1	+1	+5	+7	9	11	13

The straight line AB (*Figure 16*) is the graph of $2x + 3$, and it is obtained by plotting columns 1 and 2.

If the reader will plot out a number of these graphs he will find that for first powers of x the curve is always a straight line.

The first constant, which is 2 in the above case, expresses the ratio of y to x; the second constant, which in the above case is + 3, indicates the point in the y-axis at which the curve passes through it.

+ 3 means that the intercept on the y-axis measuring from the origin is + 3 units above it. — 3 would mean that the intercept on the y-axis, measuring from the origin is — 3 units below it.

In *Figure 17* is given a few straight line graphs. The equations to these lines are :—

Line AB, $y = \cdot 62x + 2\cdot 9$.
,, CD, $y = x$.
,, EF, $y = 1\cdot 2x - 2\cdot 4$.
,, GH, $y = -\cdot 6x + 1\cdot 3$.
,, MN, $y = -\cdot 25x$.
,, JK, $y = -1\cdot 1x - 2\cdot 7$.

To find the equation to a straight line curve remember that it is of the order $y = mx + c$. m and c are the constants. c is the intercept of the curve on the y-axis, and is easily read off when the curve is drawn. If we measure the distance of y from the intercept on the y-axis, then m is the ratio $y : x$, or $\frac{y}{x}$, and that is really the tangent of the angle which the curve makes with the x-axis. It is usual to call this the *gradient*.

Hence gradient $=$

$$\frac{\text{Vertical distance on } y\text{-axis of any point above intercept on } y\text{-axis}}{\text{Horizontal distance on } x\text{-axis of the same point.}}$$

Thus $y = \cdot 62x + 2\cdot 9$ tells us that the curve is a straight line, and that it intercepts the y-axis above the origin a distance of 2·9 units, and gradient $= \frac{y}{x} = \frac{\cdot 62}{1}$.

Again for line CD equation is $y = x$.

C in this case is O, and the curve passes through the origin.

Also, gradient $\frac{y}{x} = \frac{1}{1}$, and this is the tangent of 45°.

When the straight line representing an equation of the first power of the variables passes through the origin, there will only be one constant involved, *i.e.*, the coefficient of x. When this coefficient is large, y increases rapidly as x increases. Thus the rate at which y increases depends on m. When $m = 1$ y increases at the same rate as x increases, when m is less than unity y increases more slowly than x, and when m is greater than unity y increases more rapidly than x. Thus if $m = \frac{1}{2}$ y increases at only half the rate that x increases. If $m = 2$, y increases twice as fast as x does. This rate of increase is called the gradient of the curve or graph, and for an equation of the first degree the gradient is numerically equal to the coefficient of x.

x may be called the independent variable, and we assume to it any value we like, to find the corresponding value of y. y is, therefore, called the dependent variable because its value depends on what value we give to x.

If an expression contains a variable, that expression is a function of the variable. Hence such expressions as $bx + c$, $3x^2 + 4$, $2x^3 + cx^2 + b$, are functions of x. Sometimes any function of x is indicated by $f(x)$, and so we have laws spoken of variously, as for example, *graph of* $3x + 3$, or $y = 3x + 2$, or $f(x) = 3x + 2$.

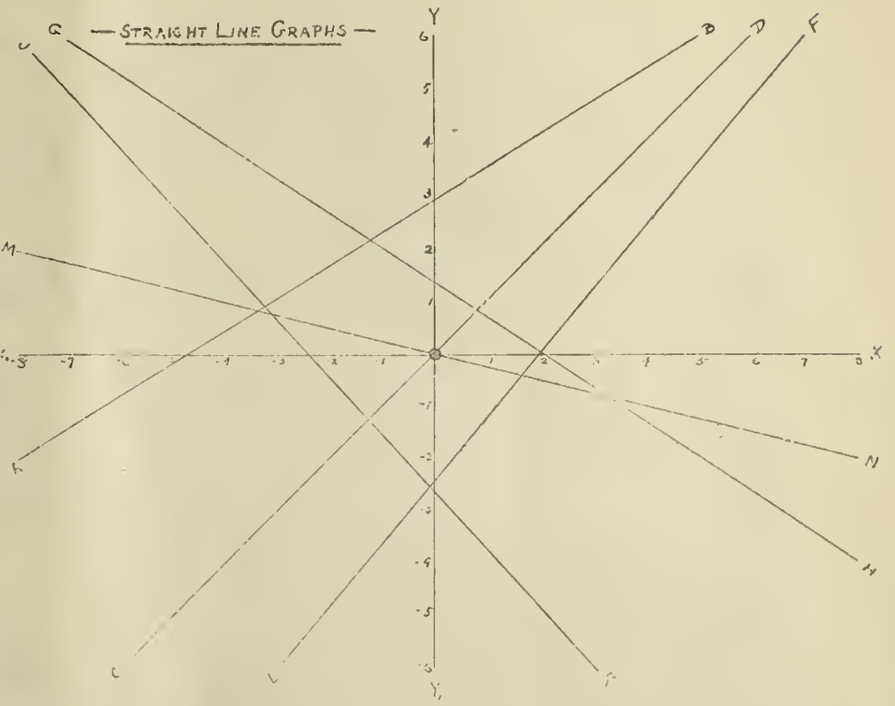

Figure 17.

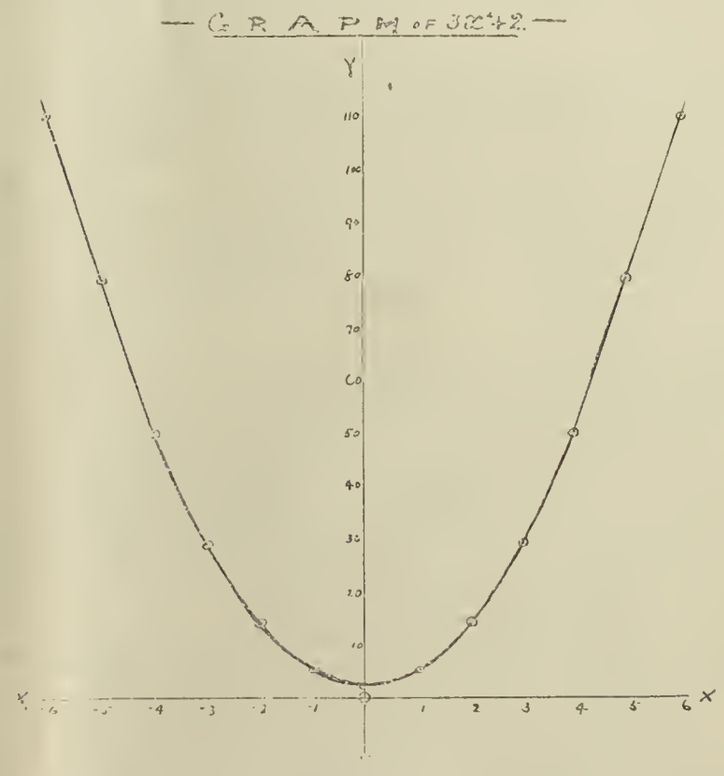

Figure 18.

The y values are, therefore, functional values, and they depend on the x values which are sometimes given the name argument on that account.

Figure 18 shows the graph of $3x^2 + 2$.

To draw it find a number of values of x and y.

When x is	6	5	4	3	2	1	0	−1	−2	−3	−4	−5	−6
y is	110	79	50	29	14	5	2	+5	+14	29	50	79	110

The reader will observe that y is always positive, for the square of a negative quantity is positive.

THE COAL MINES ACT, 1911.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

It will be opportune at this time to summarise in non-legal language the main features of the Coal Mines Act, 1911, so far as this affects the appointment, qualifications, and the duties of firemen, examiners, or deputies. Should any doubt exist as to the accuracy of interpretation, the official wording of the Act should be accepted.

The Appointment of Firemen.

Section 14.—(1). One or more competent persons shall be appointed for every mine to make such inspections, and carry out such other duties as are required by this Act, and the general and local special regulations of the mine.

These inspections and duties refer to the presence of gas, the ventilation, the state of roof and sides, the general safety of the mine, and the checking and recording of the number of persons in the mine.

They are spoken of throughout the Act as the *Statutory Duties.*

The term "competent person" means a fireman, examiner, or deputy.

Each fireman, examiner, or deputy must be appointed by the manager in writing.

(2). A fireman, examiner, or deputy shall be required to devote his whole time to the duties mentioned above, except in certain clearly defined circumstances.

His whole time is not required in any mine in which the total number of persons employed underground at any one time does not exceed thirty; or, in any mine in the counties of Durham or Northumberland; or in any mine exempted by His Majesty's Divisional Inspector of Mines owing to special circumstances.

A fireman, examiner, or deputy may still be employed to measure work done in his district, or to fire shots in his district.

In no case must the duties assigned to any fireman, examiner, or deputy *in addition* to his statutory duties (see above) be such as to prevent him carrying out his statutory duties in a thorough manner.

In no case must additional duties *be undertaken* by any fireman, examiner, or deputy, which will prevent him carrying out his statutory duties.

In any case of dispute regarding these additional duties the question shall be decided by the Divisional Inspector, whose decision will be final.

(3). The district of a mine assigned to a fireman, examiner, or deputy shall not be so large as to prevent him carrying out his statutory duties in a thorough manner.

[It should be noted that this section places increased responsibility upon the fireman, examiner, or deputy, insomuch as *additional* duties are not a legal excuse for failure to carry out *statutory* duties. A fireman, examiner, or deputy has legal power to refuse to undertake additional duties if these interfere with the efficient performance of his statutory duties. In case of dispute, the word of the Divisional Inspector is final.]

The Qualifications of Firemen.

Section 15.—(1). After January 1st, 1913, no person can be fireman, examiner, or deputy or can be appointedas such unless he possesses certain qualifications:—

(*a*) Unless he is the holder of a first or second class certificate of competency under this Act, *or* is 25 years of age or upwards, *and* has had at least five years' practical experience underground, not less than two of which have been spent at the coal face.

(*b*) Unless he has obtained from an approved Mining School, Institute, or other authority, a certificate in a form prescribed by order of the Secretary of State, stating

(*i*) that he is able to make accurate tests so far as, practical with a safety-lamp, for inflammable gas;

(*ii*) that he can measure the quantity of air in an air-current;

(*iii*) that his hearing is such as to enable him to carry out his duties efficiently.

(*c*) Unless he has within the preceding five years, a prescribed certificate to the effect that his eyesight is such as to enable him to make accurate tests for inflammable gas, and that his hearing is such as to enable him to carry out his duties efficiently.

The expense of obtaining the prescribed certificate under Section 15 (1) c shall in the case of a person employed at the time as fireman, examiner, or deputy, be borne by the owner of the mine.

(2). The certificate as to eyesight and hearing of a fireman, examiner, or deputy, shall be kept at the office at the mine at which he is employed.

Exemption under Section 15.

A competent person (see Section 14) employed in a mine in which inflammable gas is unknown shall not be required to have obtained a certificate as to his ability to test for inflammable gas, or as to his eyesight.

Exemptions under Section 123.

These apply to all persons employed as firemen, examiners, or deputies on December 16th, 1911.

Persons appointed since this date are not exempted by these provisions.

123 (*b*). Nothing in this Act shall prevent any person acting as a fireman, examiner, or deputy, if he was employed as such on December 16th, 1911, notwithstanding that

(*i*) he may be less than 25 years of age, and have had less than five years' experience underground; or

(*ii*) that he has not obtained a certificate of his ability to measure air-currents.

[NOTE.—An approved Institute, under Section 15, means one specially approved for this specific purpose by the Secretary of State. An Institute approved for other purposes under the Coal Mines Act is not necessarily qualified to conduct examinations under this section.

These approved Institutions are approved for *examination* purposes only, and not for *purposes of instruction.*

A candidate does not require to be trained or to take any course of instruction at the approved Institute at which he intends to present himself for examination.

Any candidate may present himself for examination at *any* approved Institution.

No such institute has power to refuse admission to *any* candidate, or to require him to undergo any special course of instruction previous to examination.

Candidates may prepare themselves for examination in any way they please, either by private tuition, class instruction, or by correspondence, but no such course of instruction by *any* school or authority or institute or correspondence class qualifies a person to become a fireman, examiner, or deputy. Qualification is by *examination* only at approved institutes.

As the examination will be entirely practical—there will be no written work—it is very desirable that all candidates previous to examination should endeavour to obtain instruction at some centre having suitable apparatus, in order to make themselves familiar with its use. They will be examined with such apparatus, and the value of experience in the use of it, previous to examination, should be obvious.

The examination in the prescribed subjects will be thorough.

All candidates not exempted under Section 15 will be required

(1). To demonstrate to the examiner the *mode of procedure* for detecting inflammable gas by means of a safety-lamp.

(2). To make correct observations of "gas caps" by *various* percentages of fire-damp, with various kinds of lamp, burning various kinds of oil.

All candidates not exempted under Section 123 (*b*) (*ii*) must show

(1). Ability to measure the velocity of the air-current passing

(*i*) by means of the anemometer; *and*

(*ii*) by means of dust or smoke; also

(2). To calculate the area of the cross section of the gallery in which the air to be measured is passing.

The hearing of *all* candidates (no exemptions) must be such as to enable them to detect the movements of the roof and

sides when subject to pressure, the cracking of timber, and the like. It will not be required that a fireman should possess a standard of hearing above that of the average man, nor is it required that his hearing must be up to the standard in both ears.

Each candidate will be examined separately.]

The prescribed form of certificate under Section 15 (1) (*b*) is as follows :—

Certificate of Qualification of Fireman, Examiner, or Deputy under section 15 (1) (*b*).

This is to certify that residing at has been duly examined, and has satisfied the examiners

(1) (*a*) That he is able to make accurate tests (so far as practicable with a safety-lamp) for inflammable gas ;

(2) (*b*) That he is able to measure the quantity of air in an air-current ;

(*c*) That his hearing is such as to enable him to carry out efficiently the duties of fireman, examiner, or deputy.

(Signature of person authorised in that behalf by the approved School, Institution or Authority) .....

Date .....

Name of approved School Institution or Authority .....

(1) (*a*) is to be struck out in the case of a candidate producing a certificate from the manager of his mine that he is employed in a mine in which inflammable gas is unknown.

(2) (*b*) is to be struck out in the case of a candidate producing a certificate from the manager of his mine that he was employed as a fireman, examiner, or deputy on the 16th December, 1911.

The form of the prescribed certificate under Section 15 (1) (*c*) has not yet been issued by the Secretary of State.

The following communication from the Home Office has been received :—

The Home Secretary gives notice that he has approved the following Mining Schools, Institutions, and Authorities for the purpose of granting certificates to firemen, examiners, and deputies under the provisions of Section 15 (1) (*b*) of the Coal Mines Act, 1911 :—

Scotland.

Heriot-Watt College, Edinburgh.
Royal Technical College, Glasgow.

Newcastle and Durham Inspection Districts.

Cumberland Education Committee.
Durham County Education Committee.

York and North Midland Inspection District.

Barnsley Education Committee.
Batley Education Committee.
Cleckheaton Technical Institute.
Dewsbury Technical School.
Doncaster Education Committee.
Huddersfield Technical College.
Nottinghamshire Education Committee.
University College of Nottingham.
Wakefield Education Committee.

Manchester and Ireland, Liverpool and North Wales Districts.

Accrington Education Committee.
Ashton-in-Makerfield Urban District Council Higher Education Committee.
Atherton Urban District Council Higher Education Committee.
Burnley Education Committee.
Leigh Education Committee.
Manchester Municipal School of Technology.
St. Helens Education Committee.
Tyldesley Higher Education Committee.
Wigan and District Mining and Technical College.
Worsley Urban District Council Higher Education Committee.

South Wales Inspection District.

Glamorganshire Education Committee.
Merthyr Tydfil Education Committee.
Monmouthshire Education Committee.

Midland and Southern Inspection District.

Gloucestershire Education Committee.
Leicestershire Education Committee.

No person will, after 1st January, 1913, be eligible to be appointed or to act as a fireman, examiner, or deputy unless he possesses a certificate from an approved School, Institution, or Authority. This requirement will apply to existing firemen, &c., as well as to firemen hereafter appointed. All applications for information as to the examinations to be held for the purpose of the grant of certificates should be addressed to the approved Mining Schools, Institutions, and Authorities, and *not* to the Home Office.

The Secretary of State hopes to issue a supplementary list of approved Schools, Institutions, and Authorities shortly.

Affecting the Duties of Firemen.

STATIONS : *Section 63.*—One or more stations shall be appointed at the entrance to the mine or to different parts of the mine beyond which workmen shall not pass until the fireman has reported the district to be safe.

INSPECTIONS BEFORE SHIFT : *Section 64.*—(1). The firemen, examiners, or deputies shall within two hours of the commencement of the shift examine every part of the mine situated beyond the station or stations, in which men have to work or pass.

All working places within any ventilating district in which men have to work, that are temporarily stopped, must be examined within the two-hour period, in order to ascertain their condition as to the presence of gas, ventilation, roof and sides, and general safety.

(2). Except in the case of a mine in which inflammable gas is unknown, the inspection shall be made with a locked safety-lamp, and no other light shall be used during the inspection.

(3). A full and accurate report of this inspection shall be recorded without delay in a book to be kept for the purpose.

The report shall specify whether or not, and, if any, where *noxious and inflammable* gas was found ; also, what defects in roof or sides, and other sources of danger were observed during the inspection.

This report must be signed by the fireman, examiner, or deputy making the inspection, and all entries must be in his handwriting.

The report must be accessible to all workmen concerned.

(4). Two or more shifts succeeding one another without any interval are considered to be one shift, for the purpose of inspection.

INSPECTION DURING SHIFTS : *Section 65.*—An inspection similar to that described in Section 64 shall be made *twice* at least in each shift.

A report of the first of these inspections made during the shift need not be recorded.

No place shall remain uninspected for an interval of more than five hours if a mine is worked by a succession of shifts.

COPIES OF REPORTS : *Section 17* (2).—Reports made under Sections 64 and 65 shall be posted at the pit-head, and remain posted for not less than 24 hours.

The copies must be posted not later than ten o'clock in the morning of the day following the day on which the reports are made.

COUNTERSIGNING REPORTS : *Section 24* (2).—Every recorded report under Sections 64 and 65 shall be submitted to the manager *and* under-manager, and shall be countersigned by them on the day on which the report is made, or the day following.

VENTILATION : *Section 29* (1).—An adequate amount of ventilation shall be constantly produced in every mine to dilute and render harmless inflammable and noxious gases to such an extent that all parts of the mine are in a fit state for working and passing therein.

The amount of ventilation shall be such that the intake airways, up to within one hundred yards of the first working place in a ventilation district, shall not contain more than one-quarter per cent. of fire-damp.

(2). In every mine the quantity of air in the main current shall, at least once in each month, be measured and recorded in a book for the purpose.

Similar measurements shall be made and recorded for every split and at such other points as may be determined by the regulations of the mine.

(3). The quality of the air circulated must be such that it contains at least 19 per cent. of oxygen, and not more than 1¼ per cent. of carbon dioxide.

If a mine is liable to "gob-fires," the Secretary of State may, by order, grant an exemption from the required quality of air.

Section 30.—As an additional obligation to that under Section 29 (1) the *minimum* quantity of air passing into a mine may be prescribed by the general regulations applicable to that mine.

Withdrawal of Workmen: *Section 67.*—(1). If at any time the person in charge of a mine, or any part of a mine, detects danger due to noxious or inflammable gas, or to any other cause, the workmen shall be withdrawn from the mine or place found dangerous.

A fireman, examiner, or deputy shall inspect the mine or place found dangerous, and shall make a full and accurate report of his inspection.

If the danger arises from inflammable gas the inspection shall be made with a locked safety-lamp.

No workman, except in so far as is necessary for inquiry into or removal of the danger, shall be allowed to enter the mine or place found dangerous until the same is reported by the fireman, examiner, or deputy, not to be dangerous.

(2). In safety-lamp mines, a place is considered dangerous if 2½ per cent. or upwards of fire-damp is found in the general body of the air in that place.

In naked light mines 1¼ per cent. or upwards is considered to be dangerous.

(3). The report, referred to above in sub-section (1), shall be recorded in a separate book, and signed by the person making the inspection.

(4). If a workman discovers fire-damp in his working place he shall immediately withdraw therefrom, and inform the fireman, examiner, or deputy.

Safety-Lamps: *Section 32.*—(1). No lamp or light other than a locked safety-lamp shall be allowed or used—

(*a*) In any ventilating district in which the return air-way contains more than ½ per cent. of fire-damp.

(*b*) In any seam in which a fire-damp explosion causing personal injury has occurred within the previous twelve months. (See exemptions).

(*c*) In any place in a mine in which there *is likely to be* any such quantity of fire-damp as to render the use of naked lights dangerous.

(*d*) In any working *near to* or *approaching* a place where there is likely to be an accumulation of fire-damp.

(*e*) In any place where the use of safety-lamps is required by the general or local special regulations of the mine.

(2). Where safety-lamps have been installed it is not lawful to use naked lights on the return side of the place where they are used, except in cases where safety-lamps have been introduced as a temporary precaution.

(3). When safety-lamps have been introduced in any part of a mine the sanction of the Divisional Inspector is necessary before their use can be withdrawn.

If introduced as a temporary precaution the Inspector need not be consulted.

(4). The percentage of fire-damp normally contained in the air shall be determined by the analysis of samples.

(5). If safety-lamps are in use in any seam, they shall also be used in the cross-measure drift connected with that seam.

Approved Safety-Lamps: *Section 33.*—After January 1st, 1913, no safety-lamp shall be used except it is of a type approved by the Secretary of State.

Examination of Safety-Lamps: *Section 34.*—(1) (*i*). Previous to any lamp being given out for use it must have been examined at the surface by a competent person. No lamp shall be given out unless it is found to be in safe working order.

Each lamp shall be securely locked, and a record kept of the man to whom it has been given.

(*ii*) Each lamp shall be examined on its return by a competent person. If found to be damaged a record of the damage shall be made. Any damage to a lamp shall be deemed to have been done by the person to whom it was given out, unless he proves that the damage was due to no fault of his own, and that he immediately gave notice to the fireman, examiner, or deputy.

(*iii*). A safety-lamp shall not be unlocked except at an appointed lamp station.

This appointed lamp station shall not be in a return air-way.

A competent person shall be appointed to unlock, examine, and relight lamps.

No person other than this shall have in his possession any contrivance for relighting or opening the lock of any safety-lamp.

(*iv*). No part of a safety-lamp shall be removed by any person when the lamp is in ordinary use.

(2). Where any damage is done to a lamp in use through the neglect of the person to whom it was given out, that person shall be guilty of an offence against this Act.

Prohibition of Matches, &c.: *Section 35.*—(1). No apparatus of any kind for producing a light or spark is permissible in any part of a mine in which safety-lamps are used.

The Secretary of State by an order may authorise apparatus for shot-firing or relighting lamps.

(2). All or any persons entering a part of a mine using safety-lamps are liable to be searched in a prescribed manner after or immediately before entering.

(3). No person shall search a workman unless he himself has previously given an opportunity to some two workmen to search him.

(4). Any person refusing to be searched in the prescribed manner shall be guilty of an offence against this Act.

[Note.—The manner of search has been prescribed in an Order by the Secretary of State dated May 21st, 1912, and is as follows:—

(1). The search shall be made by a person, or persons, appointed for the purpose in writing by the manager.

(2). In the case of members of a shift the search shall be made in the presence of two or more members of the shift.

(3). The search shall be made with due regard to propriety, and so as to occasion the person searched as little inconvenience as possible.

(4). The person conducting the search shall—

(*a*) search or turn out all pockets;

(*b*) pass his hands over all clothing;

(*c*) examine any article in the workmen's possession.

(5). If the person conducting the search suspects that the person searched is concealing any prohibited article, he shall detain him, and as soon as possible refer the matter to the manager, under-manager, or other official authorised by the manager for the purpose, who shall not allow the person to proceed to work until he has satisfied him that he has no prohibited article in his possession.]

(*To be Concluded.*)

TESTING UNDERGROUND HORSES.

An Order of the Home Secretary, dated May 17th, 1912, issued in pursuance of the Third Schedule to the Coal Mines Act, 1911, prescribes that horses before being taken underground shall be tested for glanders by a duly qualified veterinary surgeon in the following manner:—(1) The test shall consist of the hypodermic injection of mallein, followed by the taking of the temperature of the animal at the 6th, 9th, 12th, 15th, and 20th hours respectively after the injection. (2) The animal to be tested shall rest for 24 hours before the test is applied. (3) The physiological variation of the animal's temperature shall be noted before the test is applied. (4) The test shall not be applied to any animal while showing an abnormal temperature. (5) The animal shall not be worked for a period of 30 hours after the injection. (6) The mallein used for the test shall be obtained from the Royal Veterinary College, and shall be used in the dose specified by the College.

WHY LEAVE SHAFT PILLARS?

This was the subject of a paper jointly prepared by Mr. W. H. Pickering, Divisional Inspector of Mines, and his son, Mr. Basil H. Pickering, and presented at the 56th general meeting of the Institution of Mining Engineers. After discussing the effect of crush in coal mines and surface subsidence, also the size of shaft pillars, the Authors brought before the notice of the members the method suggested of opening a seam by the extraction of the shaft pillar, as follows :—

For commercial reasons it may be expedient to extract only the best part of a seam, but whether the whole or only part of the coal is extracted, the following are essential points that should be observed :—

(*a*) The packing to be made as tight as possible, to be of uniform structure, and to be kept close to the working-face.

(*b*) No timber or other roof supports to be left in packs or goaf.

(*c*) The tight packing to be carried beyond a vertical line drawn a selected distance from the surface buildings containing engines, &c.

(*d*) The workings to be so arranged that the "weight-breaks" due to the subsidence of the strata shall not cross the shaft.

Four methods of extracting the shaft pillar may be discussed, and it will be convenient to take a common case where the seam has been won by two shafts 150 feet apart. One method would be to start at a point between the shafts and work out the coal in a gradually enlarging circle. A second would be to drive out winning headings to a specified distance, and work back to the shafts. A third would be to take each shaft as a centre and work outwards. The writers are of opinion that the result of any of these methods would be that the weight-breaks would cross the shafts, with the result that the brick-work would be distorted, and perhaps the shafts pulled out of the perpendicular.

Weight-breaks in long wall workings keep in advance of the working face, the angle being dependent upon the nature of the strata, the thickness of the seam, the method of packing, and other factors. If work were commenced between the two shafts which are 150 feet apart, a considerable area of packing would be put on whilst the working towards the shafts was in progress. A "first weight" would be certain to occur before the faces reached the shafts, and the weight-breaks would run into the shafts. If work were commenced at each pit, it would be difficult to extract the coal when the two circles were meeting. The settlement would not be uniform, and the weight-breaks from No. 1 pit workings would cross No. 2 pit shaft, and *vice versa*. If the coal-pillar were headed out, and the coal worked in a retreating face towards the shafts, very serious damage to the shafts would result from the weight-breaks, and there would be the additional difficulty of keeping the roads and pit-bottoms open during the operation.

The method that the writers suggest is as follows :—Connect the two shafts with a heading, and produce it 225 feet or other selected distance beyond each shaft. From this heading start two long wall faces back to back simultaneously for the whole length of the heading, keeping tight packs very close to the working face. The attached outline sketch (*Figure 1*) will show the method better than any description, but the sketch illustrates the proposed scheme of working only. The arrangements for haulage and ventilation are not shown, as these will vary with conditions and with the views of the mining engineers who lay out the work.

The scheme is exceedingly simple and would be readily understood by the miners, for it follows the ordinary method of opening out long wall workings where no main road pillars are left. The faces would, from the very first, be working away from both shafts. Even with the tightest of packing there would be a settlement of the strata, but the stress at each side would be equal; and the writers believe that the shafts would settle gradually and vertically, and would be undamaged.

Great attention should be paid to the packing. Stones for the building should be carefully selected and arranged, and sand or other fine material used to fill up all the spaces. This would cushion the weight, greatly reduce the subsidence, and make it uniform. The roadside packs should be built with a batter. All timber and other roof supports should be drawn, for, if left in the goaf, they would interfere with uniform settlement. Even round the pit bottom chocks should not be used,

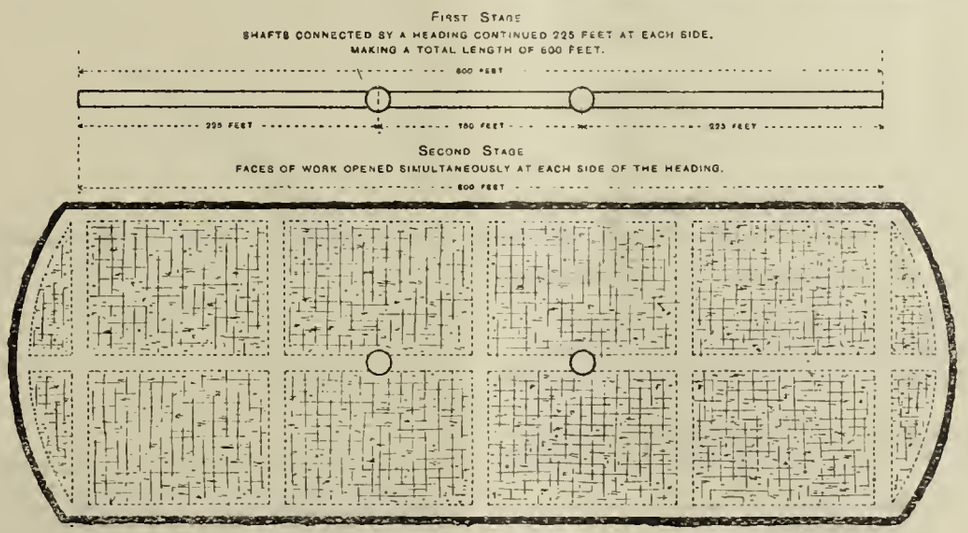
First Stage
SHAFTS CONNECTED BY A HEADING CONTINUED 225 FEET AT EACH SIDE.
MAKING A TOTAL LENGTH OF 600 FEET.
600 FEET
225 FEET
150 FEET
225 FEET
Second Stage
FACES OF WORK OPENED SIMULTANEOUSLY AT EACH SIDE OF THE HEADING.
600 FEET

Figure 1.—Plan showing Suggested Method of Extracting Shaft Pillars.

except perhaps temporarily. The material obtained in sinking the shafts and from the ripping of the roads would be largely used for the packing. In an area 200 yards square, the total length of roadway would be 1,200 yards, and if the roads were 10 feet wide and the ripping averaged 6 feet in thickness, 8,000 cubic yards of shale or rock would be produced. Two shafts 600 yards deep and with a finished diameter of 20 feet, requiring an excavation of 24 feet, would produce 60,000 cubic yards of material, making a total of 68,000 cubic yards available for packing. The area to be tightly packed would be 200 yards square. With deductions for roadways the space would be 72,000 cubic yards if coal to the thickness of 6 feet had been extracted, but many of the roadways would ultimately be packed.

It is not possible to pack a cubic yard of rock into the same space after it has been broken. A margin of about 25 per cent. would, therefore, be necessary, and consequently the 68,000 cubic yards of material would pack 90,000 cubic yards of space. Thus plenty of material for packing would be produced by the sinking and ripping. Sand might be necessary for filling up tightly the spaces between the building stones if sufficient fine material were not available. It would not be wise, however, to end the tight packing abruptly. After the specified distance had been reached, the tightness of the packing should be gradually lessened until normal working conditions were attained. When the sinking was in progress, the material produced should be carefully sorted.

In some circumstances, what is known as "hydraulic stowing" might be adopted.

About 20 feet of the bottom part of the shaft should be left unbricked, and could be temporarily secured by one of the methods adopted for temporary shaft support when sinking through bad ground.

The fact that the floor might lift in the roadways should be kept in mind, and for this reason the shafts should be sunk a considerable distance below the seam, so that the character of the underlying strata might be known. The working of the pillar should not be commenced until proper arrangements had been made for raising a considerable quantity of coal and for dealing with it on the surface when raised, as there would be a large output of coal as soon as the faces were started.

Two faces, each 200 yards long, would be opened at once, and, if the roads were 150 feet apart, there would be eight stalls. In the Barnsley Seam 20 tons of coal could be produced from each of these per shift, or a total output of 160 tons in 8 hours. Two shifts would be worked, making the daily output 320 tons from the first, and this output would increase rapidly. As it would be essential to keep the faces in a straight line, and the packing tight and uniform, it would probably be impossible to work more than two shifts a day.

It would be practicable from the first to work some seams by coal-cutting machines.

It would be useless to advocate some engineering scheme, however practicable and interesting, unless the result were profitable. The writers estimate that, taking the Barnsley Seam as a concrete example, the coal from the area usually covered by the shaft pillar could be put into wagons for 6s. 9d. a ton. If the selling price were 8s. a ton, a profit of 1s. 3d. a ton, or £62,500 for the 1,000,000 tons recovered, would be made.

Summary of Conclusions.—The writers are of opinion that :—

(*a*) In many cases it is possible to extract the whole or part of the coal from the shaft pillars.

(*b*) By extracting the shaft pillars by the suggested method a large output can be obtained within a few weeks of the seam being reached.

(*c*) The serious waste of coal left in the shaft pillars will be avoided.

(*d*) The coal will be cheaply and profitably worked.

(*e*) Crushing of the coal shaft pillars and the many attendant evils, such a gob-fires and damage to the insets and shafts, will be avoided.

(*f*) It would not be possible to extract the pillars if there were serious faults in the area such as would make the subsidence unequal.

SURVEYING.

By COLLIERY SURVEYOR.

In scale construction the student must first of all be capable of readily dividing a line into a number of equal parts. Let it be required to divide the line *AB* (*Figure 114*), which is 3 inches long, into six equal parts. If a scale of inches and parts is available, this may be done by placing the scale alongside the line, and marking off six intervals of ½ inch each. Or, in the absence of any form of measuring scale, the student might probably be inclined to proceed by a trial method with the aid of a dividing compass. Neither of these methods is correct, because in the first place the degree of accuracy attained will be dependent upon the accuracy of the scale divisions, and in the second marks and punctures are made along the line, and there is also serious loss of time in the operation. The correct method of dividing a line into any number of equal parts is as follows: Draw another line *AC*, forming a convenient angle with *AB*, and of any length. Mark off with the compass along this line, starting from *A*, equal intervals of any convenient length. Number these 1, 2, &c. Draw a line joining 6 and *B*. With the set square or parallel ruler draw lines from 5, 4, &c., to *AB* parallel to the line 6 *B*. Thus the line *AB* is divided into six equal parts. Number these 1, 2, &c. Since the line *AB* is 3 inches long, each of these parts $= \frac{3''}{6} = \frac{1}{2}$ inch. We can make this line serve the purpose of a scale of almost any value. Thus, let ½ inch on the scale represent 1 foot. A measurement equal to the length of scale will, therefore, represent 6 feet, and its representative fraction $= \frac{\frac{1}{2}''}{12''} = \frac{1}{24}$.

Let the scale now be ½ inch = 1 yard; two ½ inch intervals, *i.e.*, 1 inch on scale, represents 2 yards, and the total length of scale = 6 yards, its representative fraction being $\frac{\frac{1}{2}''}{36''} = \frac{1}{72}$.

If ½ inch to the mile the scale length would represent 6 miles, and the representative fraction

$$= \frac{\frac{1}{2}''}{1 \text{ mile}} = \frac{\frac{1}{2}''}{5280 \times 12 \times 2} = \frac{1}{126720}, \text{ and so on.}$$

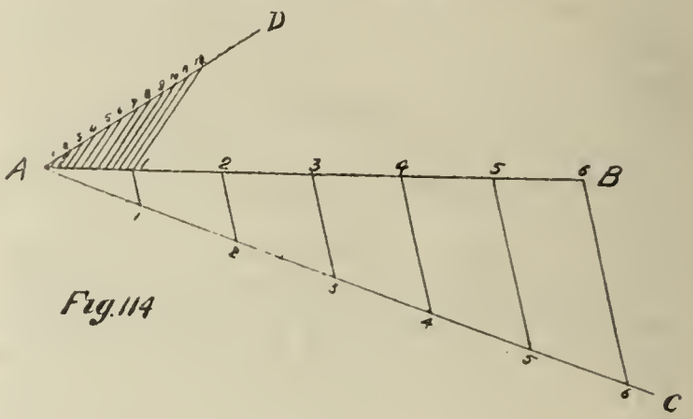

Fig.114

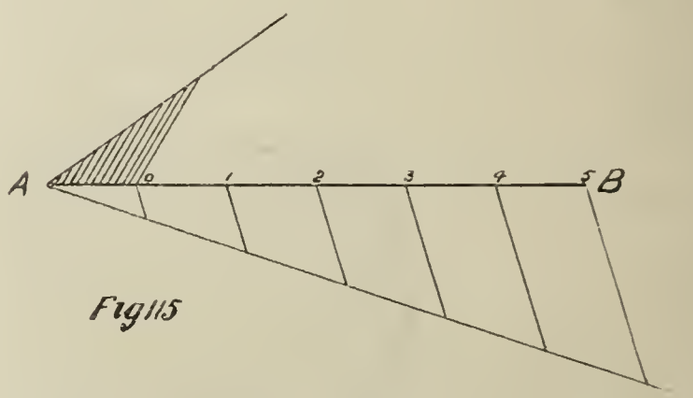

Fig115

Fig.116

Fig.117

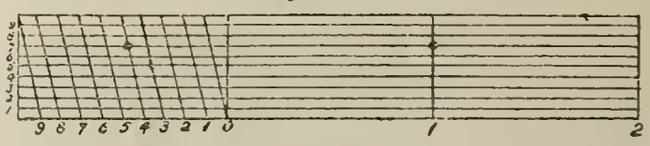

Fig.118

We will now suppose our scale *AB* to be ½ inch = 1 foot, and that it is necessary to measure inches as well as feet. The first interval *A*1 must be divided into twelve equal parts. Draw any line *AD*, and mark off upon it twelve equal intervals of any convenient length. Join 12 to 1 on scale *AB*. Draw all other lines parallel to 12 — 1. We must next alter the figuring, replacing 1 by 0, 2 by 1, 3 by 2, and so on, the end of the scale being marked 5. (*Figure 115*). The reason is obvious; suppose we wish to measure a distance of 4 feet 5 inches. One leg of the dividing compass is placed to coincide with the 4 to the right of the zero mark, which means 4 feet, and the other is brought opposite to the 5 to the left of the zero mark, which means 5 inches. We have thus an interval of 4 feet and 5 inches

spanned by the compass, whereas if the figuring was unaltered, 3 feet 5 inches might have been taken for 4 feet 5 inches.

The interval *A*1 may be divided up in another way to represent inches. It has already been remarked that a diagonal scale may be constructed to show two dimensions only. Let another eleven lines be drawn equidistant and parallel to *AB*. Cross these by the lines representing the equal parts, 1, 2, 3, 4, &c. (*Figure 116*). Draw a diagonal from 0 to the upper left-hand corner of the scale. Number the parallel lines from the bottom upwards. To measure 4 feet 5 inches on this scale we must follow the 4 feet division to the 5th parallel from the bottom; place one leg of the dividing compass at this point, and follow the line to the point of its intersection by the diagonal. Fix the other leg at this point, and this is the distance required. Similarly, if we required to scale a distance of 3 feet 9 inches, we should find the 3 feet division, and follow up to the 9th parallel line from the bottom; then follow this line as before to its intersection by the diagonal. The distances are shown by the dots on the scale. *Figure 116.*

Scales, when ready for use, are not left in single lines, as in *Figure 115*, but are usually depicted as in *Figure 117*, all construction lines being obliterated.

Let it be required to construct a scale of 1 chain = 1 inch long enough to measure 3 chains in links. In this case the principle of the diagonal scale becomes useful to find the individual links, inasmuch as it would be impracticable to divide up a distance of 1 inch on a plain scale into 100 intervals of 1 link each. Our scale will evidently be at least 3 inches long. Divide into three equal parts. Sub-divide the first of these into ten parts. We have then chains and tenths. Draw nine additional parallel lines at equidistant intervals, as shown in *Figure 118*. Mark along the top line the sub-divisions of ten links. Number from the zero of the scale as before, 1, 2, &c. Draw diagonals joining 0 and 1, 1 and 2, 2 and 3, and so on; the ninth sub-division from the bottom will fit into the top left-hand corner. It is not actually necessary to number the top line of the scale, provided the ninth sub-division at the bottom is drawn to the top left-hand corner, and all the other lines drawn parallel to this. Suppose a distance of 1 chain 47 links to be measured on the scale in *Figure 118*. The line denoting 1 chain to the right and the fourth sub-division to the left of the zero mark is found. This is 1 chain 40 links. If these lines are now followed to the 7th parallel line the space between as shown by the dots will be 147 links, or 1 chain 47 links.

The scales used in actual surveying work seldom denote less than 10 links intervals; any distance between is determined by inspection.

Examples to be Worked Out.

Readers working out the appended questions and who desire a test of their ability, should submit their answers to COLLIERY SURVEYOR, care of *The Science and Art of Mining* Office, Wigan. The answers will be examined and corrected by the writer of this series of articles, and returned privately to students with, where possible, the source of error indicated. Enclose with each set of answers for examination a stamped addressed envelope together with P.O. (or stamps) for 6d. A set of answers means answers to four questions taken from a single issue. The nominal charge of 6d. is made to meet the bare costs of examining the answers submitted. An allowance of time will be made for readers in the Colonies and Foreign countries, who may take part in this scheme, remitting by Int. Money Order 1s. (one shilling) with each set of answers to cover mailage costs, &c. Answers to the following questions where circumstances permit should be submitted to COLLIERY SURVEYOR at the convenience of readers. There is no time limit, but as far as possible readers are advised to keep in touch with the regular series of articles.

1.—(*a*) *Draw a scale of 1 chain to the inch to read links.*
(*b*) *A scale of 2 chains to 1 inch to read to 10 links.*
(*c*) *A scale of 3 chains to 1 inch to read to 10 links.*
(*d*) *A scale of 6 inches to the mile to read chains.*
Measure on the first 3·75 chains;
on the second 4·70 chains;
on the third 5·05 chains;
on the fourth 14·00 chains.

2.—*Construct to a scale of 45 feet to the inch: A scale of feet to read to 10 feet;* (*b*) *a scale of chains and links to read to 10 links. The scales should be long enough to show 400 feet or 6 chains respectively, and should be constructed to show complete divisions of 100 feet or complete chains.*—City and Guilds, Grade I., 1912.

3.—*Draw a scale of* $\frac{3}{4}$ *inch to 10 feet to measure 40 feet, or any less amount.*

4.—*Draw a diagonal scale of ·7 fathom to 1 inch, long enough to measure 10 fathoms, and showing feet and inches.*—City and Guilds, 1907.

VIEWS AND REVIEWS.

PROSPECTING FOR MINERALS: A Practical Handbook.—By S. Herbert Cox. 5s. Griffin and Co., Ltd.

The fact that a book has in a comparatively short space of time entered upon its 6th edition is sufficient proof that the writer has accurately gauged the requirements of the class he provides for. This can only be done when the Author has been through the mill himself, and has the school of experience to back up his statements. The majority of prospectors, explorers, and settlers are notoriously non-academical and matter-of-fact, and in reading through this work one realises that a practical man writes for practical men.

It were superfluous to select any points for special comment from this admirable work, which reminds us of the lucid and convincing style of the late Sir Clement Le Neve Foster; but we cannot help expressing the opinion that the chapters on "The Determination of Minerals" and "General Hints regarding Prospecting" are par excellence, and separately are worth more than is demanded for the book. It is a work which the student will revel in, and the extensive glossary at the end will prove of material use. In its present enlarged form the book, we have no doubt, will continue in great demand.

THE EFFECTS OF ERRORS IN SURVEYING.—H. Briggs, M.Sc. 5s. net. Griffin and Co., Ltd.

In this work the Author strikes out what is practically a new path. The comparative importance of various sources of error in surveying are analysed from a strictly mathematical standpoint, and practical conclusions are deduced therefrom. The Author proves that in certain of the operations of surveying the inevitable errors count for little while in other operations accuracy can only be secured by a thoroughly painstaking surveyor equipped with the most perfectly adjusted instruments.

The theory of errors is dealt with at the outset in a lucid and forcible manner, and the advantage of taking the average error rather than the probable error is fully discussed.

In the chapter on the best forms of triangles for the various problems of surveying it is shown that the theoretically best shape varies according to the nature of the work to be carried out. Thus, after going through a calculation showing the perfect shaped triangle for Triangulation purposes, the Author, after pointing out certain disadvantages, goes on to say that for all practical purposes the best form of triangle is the equilateral.

For shaft connection work Weisbach's narrow triangle as well as other forms which give best results where the narrow triangle is impossible; likewise the form of triangle that least affects the accuracy of an area, as well as that form which entails the least chaining for a given area are fully explained.

The most perfectly shaped triangle is not always the most suitable, and on page 40 we find the most economical triangle discussed. The economical triangle is defined as being the one which entails the least expenditure of time and trouble in the field.

In dealing with the "Propagation of Errors in Traversing," the subject is divided into two parts, viz.: (*a*) Errors in Measuring Lengths; (*b*) Errors in Measuring Angles.

For those who desire to follow the arguments and methods of deduction adopted by the Author in arriving at his conclusions, the book will afford instructive reading. In many countries surveys are required by law to be correct within specified limits of error, and any means by which a surveyor is enabled to calculate beforehand the probable degree of accuracy of his work is always welcome. The book before us does all this, and also points out the direction in which time can be saved in survey work without materially affecting the accuracy of the same. We think that while the busy practical surveyor will scarcely have the necessary time or inclination to follow the mathematical sequence, he can but feel that the Author has placed him under a debt of gratitude for the chapter in which the main conclusions are summarised; and also the set of tables for the computation of the average error in surveys, which occupies the concluding pages of the work.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Coal Cutting Machines.

Q.—*It is proposed to work a thin seam of coal, dipping 2 inches to the yard, by long wall, using coal cutters and face-conveyors; the roof and floor are good. Show by drawings how you would lay out a district for the above mode of working, and describe the machines you would employ.—Submitted by* "E."

A.—One important thing "E" has left out of his question is the thickness of seam, a *thin* seam being rather vague. Seams are worked with coal-cutters and conveyors of any thickness from 10 or 11 inches to 4 or 5 feet. The ideal seam for coal-cutting seems to be one having a good roof, not less than about 2 feet of coal, and below this not less than 6 or 8 inches of holing dirt with a clean parting from coal and floor. In the seam of coal proposed by "E" the roof and *floor* are good, presumably containing no dirt band, in which case it will be necessary to make the cut at floor level, removing as little coal as possible in the process of holing.

Before deciding on the actual type of machine to be used, taking the description of machines as the first part, it is necessary to note a few natural conditions, remembering that whilst one can alter the machine to make it "fit" the seam, it is impossible to alter the seam to "fit" the machine. Very often *failure* has been spelt in large letters when the real reason of such failure has merely been that the machine was unfit for the conditions it was placed in. The same construction of machine will not suit all seams, therefore a special and scientific study of the seam and the conditions of the natural forces must be made before one can attempt to place the machine on the "face." It will be seen that with no more data at hand than the conditions of an inclination of 2 inches to the yard, and a good roof and floor, it is extremely difficult to say precisely "the machines" one would employ. Since the hardness of seam and its general conditions are not mentioned, and one is left entirely "in the dark," no assumptions will be made, but different machines for different conditions will be considered, and it is hoped that "E." may find something useful in this when comparing the machine most suitable for certain conditions against the conditions of his seam, and the machine in his mind.

(1). Suppose the seam to be strong, free from "slippy" partings above the cut, and holds up easily after the cut has been made, then one would prefer a machine specially suitable for hard cutting, strong mechanically, and able to stand rough usage. For such a seam one would prefer a *disc* machine.

(2). Suppose the seam to be a tender one, and very liable to settle, or break down immediately it is undercut, then one would prefer a machine lighter than the disc, and such machine would require a less starting effort than is necessary for the disc. The machine most suited here might be of the *chain* type.

(3). Suppose the seam to be a tender one with an easily available band of dirt not too hard for holing, then one might prefer the *bar* type of machine.

For the conditions mentioned the respective machines may be successful, but many are not; it may be beneficial to look for a moment at the fitting together of the machine selected, and the natural conditions likely to be met with. It must be remembered than in the ordinary evolution of improvements, machine holing takes the place of hand holing, bearing out the principles of holing in a more perfect way. If machine holing is to be effective, then, it must be of such a character that it possesses the same principles as hand holing, but at the same time carrying those principles to a more advanced stage, scientifically, with economy and safety. Everyone knows, who has any experience of hand holing, that the best results are only found when the holing is carried to a definite line of break, or "back." When the line of face is practically straight, *i.e.*, the line of face parallel to the line of break, not only are the best results produced, but such lines are found to run regularly, so that once found the most economical depth of holing is easily maintained. What this exact depth is will, of course, depend on the natural laws appertaining to the seam and its adjacent strata. In hand holing, if a seam is undercut to a depth of 5 feet, and the sprags or artificial supports are withdrawn, and the coal does not fall, then in ordinary circumstances it may be found that the coal may readily fall if the supports are re-fixed and the coal undercut, say to 6 feet. The experienced collier will know, generally without saying so, that the breaking-depth of the seam has not been found at 5 feet; once, however, the proper breaking depth has been gauged, his experience will indicate to him that he must strictly adhere to that gauge, and his holing must be "backed" up to that clearly and regularly. Failures and losses resulting in attempts to introduce coal-cutting machines are often caused by the desire to introduce some particular type of machine, and attempting to make the seam or mine suit that particular type. The conditions of one seam differ so much from the conditions of another that it is hardly expected that because some particular machine has been eminently successful here, it is going to be just as successful there; "the design of the machine must vary in accordance with the requirements of almost every conceivable condition." Before deciding on a design several natural and important questions must be decided, and in this the manager will do well to consult his subordinates. Very often it is the deputy who knows most of the details of working his seam. Suppose we examine some of the conditions of importance, it will certainly help our readers, and may give them useful ideas. If a machine is particularly successful its employers do not always seek the reason of its success; they are generally satisfied by giving a sound recommendation of the particular type used. If a machine proves an "utter failure" in a particular seam, its employers sometimes study the reason of its failure, and may find a way out of the difficulty, sometimes condemn the machine, but generally do not condemn their own shortsightedness.

What are the reasons for employing coal-cutting machines? The chief reasons probably are that the use of machines minimises the loss of life at the coal face, and at the same time produces general economy, and often a saving of cost with increased selling value of the coal obtained. It is easily possible to keep a straight line of face allowing of a systematic and scientific control of the roof pressure; and to work the coal in that direction which gives a maximum amount of round coal with its increased selling value. Note the following results from a paper on "Coal-Cutting by Machinery," by Mr. H. Baddeley, read before the Yorkshire Branch of the National Association of Colliery Managers, in 1903. He stated that he had reduced the actual getting coal, effected a substantial gain in getting coal of a better selling value, and increased the output of coal from a given length of face. He had also effected a saving in timber, made ventilation and supervision easier, reduced the number of shots in the coal, made the work at the face easier for the miner, produced a better and more systematic system of timbering, and created a reduction in the number of accidents. These results were obtained in a 2 feet 10 inches seam, in which a shallow cut of 3 feet had only given indifferent results, but when he introduced a 5 feet 6 inches undercutting machine he had gained immediate advantages. It might be added that the average output here per man increased from 3½ tons to over 8½ tons per day, the average advance of the face being 27½ feet per week, *i.e.*, 5 cuts of 5½ feet each.

Mr. W. E. Garforth, in a paper on "Coal-Cutting by Machinery" (Trans. Inst. of Mining Engineers), records an increased output from 3¼ tons per man per day by hand to 6 tons per man per day by the Diamond Machine, and a reduction in getting price from 2s. 1½d. per ton to 1s. 3½d., a saving of 10d. per ton. In this case the seam was 4 feet thick, and the coal was undercut to a depth of 5½ feet.

The advantages to be gained by the use of coal-cutting machines are many, as shown by reports and statements of experience, and may be summarised as follows:—

(1). Increased safety by always keeping the "face" protected by a thorough system of freshly set timber.

(2). A sufficient stock of freshly holed coal always ready, ensuring keeping the pit and haulages always up to their full capacity, and ensuring a regular output.

(3). Owing to being able to work the coal "end on" with a quick advance of face, crush on the coal is somewhat pre-

vented, and a greater proportion of cubical or "round" coal is obtained, demanding an increased selling price.

(4). Since the machine does the holing—the more arduous work—the cost of production is decreased, extra time is allowed for filling coal, and consequently the output per man per day is increased.

(5). For a given output from a given length of face fewer men are required at the coal face, with consequent less liability for compensation, &c.

(6). Output more regular and consistent than with hand holing, and may be increased by extending the face. More regular output is more consistent with higher wages per man, with less liability to "make-up" to minimum wages.

(7). Holing may be done in dirt, either dirt band in seam, or in dirt floor, which dirt is often too hard to hole by hand with any degree of economy.

(8). The increased and more regular output brings about cheaper haulage and dead work. The more regular and systematic method of working, unless interfered with by faults, &c., conduces to more regular and "planned" haulages.

(9). The ventilation of the whole mine is better, and more easily maintained, due to straighter faces, less corners and obstacles and shorter faces.

The disadvantages, on the other hand, may be set against the machines as :—

(1). Holing of less height than hand holing, only about 5 inches against 18 or 24 inches, not allowing in some cases a fall of coal so clearly or easily as in hand holing. This along with the fact that the coal, owing to its slight fall, does not break up so easily, may necessitate an increased number of shots. But as such shots are in many cases merely pop-shots, it may be that a no greater total weight of explosive is used than in hand holing. On the other hand, it might be argued that a greater number of shots gives a liability to a greater number of miss-fires, and other risks.

(2). Increase of timber cost. A more rapid advance of face necessitates a more constant setting of timber, but since the timber is not kept in direct face action for long due to the face rapidly advancing, less may be broken and much may be used again after recovery from the goaf. This is specially so where tapered timber is used under favourable conditions for its principle.

(3). Increased capital account due to the erection of extra power plant, &c., together with increased attendance and repairing costs. Increase also in fitting shop plant and wages, due to repairs of machines, repairs of cutters, maintenance of plant.

(4). Increased consumption of coal due to extra power required.

(5). Dangers attending the use of coal-cutting machines due to inflammable gas where electricity is used as the motive power. This, with an adequate system of ventilation, which would be made easier by the more scientific method of working, need not produce much alarm unless the unexpected, in the form of a sudden outburst, or blower, occurs. It is as easy to be on the alert for inflammable gas in machine work as in hand work; it is easier to thoroughly dilute the gas as given off ordinarily in most mines, and it is easier to prevent accumulations of gas.

(6). What is the worst feature in some cases, the difficulty of fixing a suitable price list.

Comparing the advantages with the disadvantages, it goes without doubt that the application of coal-cutting machines affords the means of deriving the greatest economy; the greatest benefits being derived from a thin seam with a generally good roof (although any seam can be worked by machines on a straight face if such can be worked on the straight face by hand). It is better if the roof is a bending one, and the inclination of the seam is not too great. The seam mentioned in question seems an ideal seam for the purpose, but much as to the type of machine to be introduced will depend on the *strength of the coal*, its *freedom from "brasses,"* or iron pyrites, and, if electric power is proposed, its *freedom from water* and large and *sudden outbursts of inflammable gas.* The ideality of the seam would be greatly enhanced if it possessed an available dirt band for holing in, say from 4 inches to 10 inches in thickness, free from ironstone or brasses.

Now to the type of machine to be introduced. There are so many specialised types that it is not the intention here to single any one out of them. If the seam is a fairly hard one it would be advisable to use the *disc* type of machine, with a cutter wheel sufficient to cut to the best depth found to be most advantageous. The depth of holing most suitable to take advantage of the effect of natural forces may be found easily, or may be found only by trial experiments. It is better to study the natural conditions of the seam and its roof and floor, and to find the ideal depth by experiment, than to discard the machine with a grumble because the happy thing leading to success has not been hit upon at first attempt. Many machines have been introduced, and tried, and altered, and tried again before the natural answer to the natural conditions has been found. When the proper depth of holing has been decided, it will generally decide, also, the exact position where the cut must be made. The depth of under-cut also indicates the form of machine as regards height, width, and other important details of construction. The disc type is probably the better for most classes of work, and may be constructed to run on rails or sledges, but where possible rails are the better. The machine should be arranged to cut either way, and cut to any depth desired with little alteration; the height of the cut should be such as will allow for a complete vertical fracture between the undercut and solid coal, so that the coal will have little chance of becoming wedged when the floor lifts or the roof subsides. Great care should be taken, especially if the holing is hard, not to have a machine that is too light for its work; the desire of many may be to have a machine of light construction, but experience has taught long users that the machine which has to serve as its own foundation must contain the necessary weight to allow sufficient strength and power to be produced to excavate the coal or dirt at a minimum cost, and to maintain the proper line of cut. Lightness is seldom an advantage in coal-cutting machines. The machine selected should be as equally balanced as possible, and the cutter wheel as near the centre of the machine as possible; it is found that machines which are heavier at one end than the other are inclined to mount up into the coal and leave the rails when used light end first. The cutter tool should be simple, easily interchangeable, and as easily made by the colliery blacksmith. It is also important that if the desired amount of work is to be got out of the machine it must be constructed with the best and most suitable material, and by the best workmanship, and even slight repairs should be attended to without delay. Many machines on the market will be found to answer this description, such as, for example, the Diamond, Gillott and Copley's, Clarke and Steavenson's, &c.

Concerning the motive power, that opens up another direction of thought and experience, though only two powers are available, compressed air and electricity. In the first, one has a very safe and simple power, but proportionately costly; in the second one has a power much less costly in transmission and more economical, but coupled with these advantages one has to cope with the danger attending its use, which danger has, no doubt, been exaggerated to some extent. Experience has shown that where the difficulties and dangers attending the use of electricity can be got over, its use effects a great saving over the use of compressed air. In some cases, advantage is being derived from using electric power at some part of the mine in the "safer zones" to drive compressors, and then conveying compressed air through comparatively short distances to the coal-cutters, thus avoiding the great loss due to transmission from the surface. This is, of course, an action which depends on the natural conditions of the mine, and the opinions of the management.

This answer has been purposely extended on the opportunity of giving greater insight into the use of coal-cutting machines, and the advantages to be derived therefrom, to the many colliery deputies, students, &c., who read this Journal; and to also show that unless all the conditions of a seam are given or assumed, one cannot say which is the best type of machine to put in, or the best motive power to use. It is hoped that the points raised, coupled with conditions of the seam known to "E," will be helpful to him in deciding on the right kind of machine. The answer will be continued in next issue, with sketches showing the laying out of the workings for general coal-cutting and the use of conveyors.

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GLAMORGAN COUNTY COUNCIL.

APPOINTMENT OF LECTURER IN MINING.

The Education Committee Require the Services of a MINING LECTURER.

The candidate appointed must be qualified to teach the subjects of the Glamorgan Mining Course ; must reside where directed by the Committee, and devote his whole time to his duties.

Salary, £150 per annum, rising by annual increments of £10 to a maximum of £200 per annum, together with travelling expenses according to scale.

Canvassing directly or indirectly will disqualify.

Applications, made on forms which may be obtained on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, COUNTY HALL, CARDIFF, not later than the 18th June, 1912.

The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, JUNE 22, 1912.

THE STONE DUST REMEDY.

At the 56th general meeting of the Institution of Mining Engineers, Mr. W. E. Garforth discussed the risks from coal dust in mines in his presidential address. He said that by far the most important series of experiments at Altofts were those connected with what has come to be known as the stone dust remedy, and in this connection he briefly described the observations made during the recovery of the Silkstone Pit after the explosion in 1886. These showed that wherever coal dust was found great damage was done, but wherever the explosive blast encountered stone dust roads the force diminished and the flame rapidly died out. Many stoppings between the main intake haulage roads and the return air-ways were blown out, and coal dust was projected into the returns where such gas as was made in the mine was found. No signs of flame or force were seen on these returns, except immediately where a stopping had been blown out, showing that the stone dust naturally present on the returns was effective, not only in diluting the coal dust projected into them by the blast, but also in counteracting the added inflammatory influence, say one per cent., of fire-damp. Having observed that stone dust had such a deterrent action, it was but natural, when the experimental gallery was available at Altofts after a lapse of 22 years, that he should propose to the Coal Dust Committee of the Mining Association that experiments should be made with stone dust. By the phrase "stone dust" he implied "argillaceous shale" or clayey bind dust. By these experiments he claimed that the proof of the value of stone dust was established. But this proof is of mere academic interest unless the remedy can be easily and cheaply applied, without interfering with the health of the workmen, or introducing any fresh danger such as falls of roof and sides. The management of the Altofts Collieries have now had 3½ years of practical experience in the application of stone dust in their mines. The principle which they have adopted is to strew stone dust wherever there is coal dust, that is, on all the mechanical haulage roads, the neighbourhood of junctions where tubs bump against each other, &c. Twelve and a half miles of such roadway have now been treated. The stone used is obtained from the "ripping" of the roof of one of the seams, is ground to dust in a pulveriser on the surface, sent down the pit in tubs, and distributed by hand by youths working with their backs to the ventilating current to prevent unnecessary inhalation of any of the dust. To give some idea of the fine state of division of the stone dust which checked the blast in the Altofts explosion of 1886, Mr. Garforth mentioned that the corpse of Lomax, one of the deputies, was not recovered until eight weeks after the explosion. Whilst leading an exploration party Mr. Garforth noticed a number of fine markings on the settled stone dust, similar to those made by small worms on the silt or fine mud in a garden. Those proved to be the impressions of the tails and feet of mice which had partly eaten the body, a fact which gave some idea of the fineness of the stone dust, and of the consequent large surface of inert matter exposed to the action of the flame.

Near the pit bottom and main junctions the first dressing of stone dust is sufficient to fill up all the ledges and crevices, and it is not then so easy for more coal dust to be deposited. Where screens are situate near the downcast pit, and coal is carried into the mine from the surface, extra heavy dressings are applied. As soon as the stone dust surface is overlaid with a film of coal dust a brush, or "brush-rake," is passed over the surface exposing fresh stone dust. When this surface has been again overlaid by coal dust, a fresh dressing of stone dust is applied. On the ordinary haulage roads the dressings of stone dust do not need to be so frequent. Many ways of applying it have been tried, but none has proved so successful as application by hand. During the first twelve months of practical application of stone dust at Altofts the cost amounted to only one-eighth of a penny per ton of coal raised. The management have since gained sufficient experience to reduce this cost materially. During 1911 and the five months ending May last the cost per ton of coal was less than one-twentieth of a penny, and in two seams was less than one-fiftieth of a penny. There is no objection to the use of this dust where electricity is used, for even if falls of roof occur, resulting in injury to cables and open sparking, no explosion would result where stone dust is properly applied, as with the coal dust it would form a non-explosive mixture.

Mr. Garforth then said that none of the different dusts which had been experimented with fulfilled so well the conditions of a material suitable for dusting a mine as clayey bind dust. Being a bind of the coal measures, it is found at all collieries, and is cheap and easily pulverised, with a specific gravity suitable for its work, and with particles more or less rounded and not glassy. The percentage of magnetic iron in it is low. The cool nature of clayey bind dust renders it easier to handle than flue dust, and it is not so unpleasant to taste nor so injurious to breathe. As to its effects on the workers, he quoted Dr. J. S. Haldane, who stated that "the stone dust used at Altofts was from soft shale, and was certainly not of such a nature as to give rise to any anxiety as to the effects produced by inhaling it, particularly as the amount inhaled would be small."

The main points in the address are thus summarised :—

That as a result of the British coal dust experiments, the explosive character of coal dust *per se* has been demonstrated and definitely established.

That the chemical and physical phenomena of coal dust explosions have been studied, and accurate data have been obtained concerning the pressure developed, the velocity with which the pressure is propagated, and the products of combustion.

That the efficacy of an inert dust as a diluent of coal dust has been repeatedly proved.

That individual research has shown that by reason of the existence of highly inflammable resin bodies, coal dust may be even more dangerous than is commonly imagined, and that there appeared to exist in some coals spaces which form reservoirs of gas under great pressure.

That exhaustive examination of several substances which have been suggested as diluents of coal dust show that, whereas the dust of any inert substance, provided it be of not too high a specific gravity and in a sufficiently fine state of division, will serve the purpose of a preventive if its value as a diluent be alone considered, physiological considerations must also be taken in conjunction with efficiency and economy.

NOTES FROM WALES.

By BRYCHAN.

Haulage—(continued).

Wherever ropes are carried upon pulleys, large or small, great care should be taken to safeguard against the possibility of their slipping from the tread on to the spindle or axle. In this respect, swinging sheaves are very undesirable, unless the clearance between the sheave and the side of the carrying bracket is very fine. For a rope to become jammed between the side of the carrying bracket and the sheave means disaster if unobserved and the rope allowed to work in that position, especially if the rope is to some extent worn, with a few broken wires here and there. If, in passing round a sharp bend, or around the return pulley, or some such situation, the rope slips on to the pulley axle, this means complete ruin of the rope for the distance traversed while in that position. Swinging sheaves are not necessary on straight planes, but their use cannot well be avoided if the plane is tortuous.

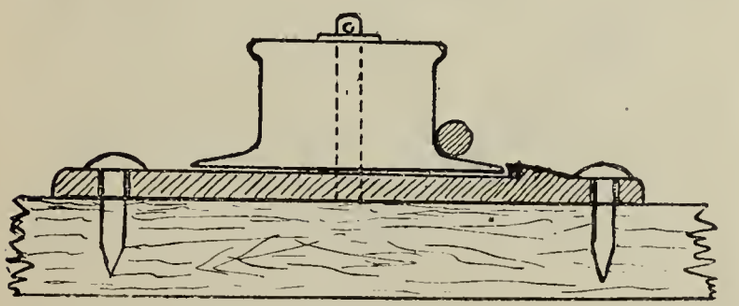


Figure 157.

In the case of planes that are not straight, but decidedly tortuous, as is generally the case with water levels, provision is sometimes made to keep the bottom or trailing rope in the centre of the roadway. This is done by fixing in the centre of the road at every bend one or more single flanged or unequal flanged pulleys, locally termed "boxhats" and skew sheaves. *Figures 157* and *158* show a good example of each. These allow the rope to slip off easily when the journey approaches

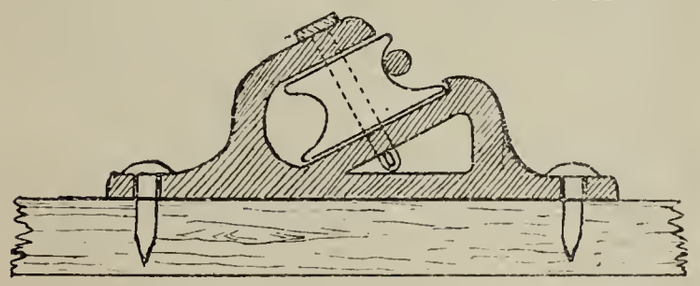


Figure 158.

that point. It is the runrider's duty to see that the rope is led on to each of these pulleys. It too often happens, however, that, either through indifference or through an insufficiency of slack rope, he fails to do so. That is to say, he fails to *sheave* the rope at these points. The result is that the rope is free to approach the side of the roadway, which may cause a derailment of the set when travelling in the opposite direction, besides causing abnormal wear of the rope. It is far better not to rely on the caprice of the attendant in this respect, but relieve him entirely of the work by providing side rollers alongside and outside of the track to receive the rope, there being just the required clearance left between these rollers and the ends of the tram axles. In this case also, since the pull of the rope is out of the centre line of the roadway, the tendency will be to cause derailment of the tubs, but this can be met by elevating the inner rail on the curve, or putting in some form of check rail, or both.

TALES OF THE COAL TRADE.

The subject of coal can hardly be mentioned without reference, direct or indirect, to the traditional wiliness of the merchant. But it is not by any means always the consumer who is "done." The present writer recently saw a small merchant suffer in this way. The steamer discharging his cargo was to be emptied before six o'clock in the evening or demurrage charges came in force. Working the regulation number of men there should have been no difficulty in so doing. Somehow, however, everything went wrong. The men would not be hurried, and at six o'clock the harassed merchant consented to let the ship depart rather than pay the demurrage and overtime to the lumpers. He told me that the steamer took twenty tons of his coal to sea again. In a Mediterranean port not long since the writer came across a case where the cargo from England weighed out sixty tons short of the shippers' bill of lading. This, astonishing as it seems, was attributed to the alleged fact that, owing to the addition of heavy wood and iron strengthening pieces to the colliery trucks since their emergence from the building shed when their original "tare" weight was registered, they were more frequently than not incorrectly allowed for on the weigh-bridges, and those strengthenings consequently paid for over and over again as coal.—*The Weekly Telegraph.*

ROPE-DRIVEN COAL-CUTTERS.

In a paper before the Institution of Mining Engineers Mr. Wilfrid L. Spence described a wire rope-driven coal-cutter he has designed. He claims that a rope-driven coal-cutter may attain almost ideal elementary proportions without either loss of capacity or of mechanical efficiency, and that such a machine will be appropriate to its environment in a way that no electrical machine ever can be for long. For the rope-driven machine it is claimed: (1) That it is simple. In addition to the cutting-wheel, there are only two pinions, two rope-pulleys, and two clutches as the essentials. There are no running shafts and no horizontal bearings; there are no keys or keyways, and there is no feed-gear apart from the main drive. (2) That it is very accessible. All the gearing subject to wear is removable in two single units, and any wear is made good by simply relining with white metal. (3) That it is easily maintained. The picks are renewed by grinding only, without smith-work, and oiling once or twice a week should be adequate for the machine itself. (4) That it is a particularly safe machine. The silent operation will tend greatly to the avoidance of dangerous falls. The running ropes are guarded, so that frayed wires in an old rope will not endanger the workers. The machine is completely controlled from the front end. The machine cannot run down on a steeply inclined working. It is incapable of causing explosion or shock. (5) That the dimensions (15 inches in height by 2 feet 9 inches in width) make it of almost universal application; it will go anywhere, and on account of the possibility of applying almost unlimited power, it should cut anything met with in a coal mine. The narrowness in a thick seam facilitates the hutches being run along the face, if desired, and in all cases it is of great advantage as regards roof maintenance and the operation of conveyors. The detachable ends and the special rail-skids facilitate transport and flitting along roadways. (6) That it is economical. There are no supplies, no brushes, no slip-rings, no switch-contacts, no fuses, and no trailing cables to renew. But little oil is required, and the perfection of lubrication eliminates wear from the main transmission system.

PRIZE COMPETITION.

" Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, July 2nd, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 24, Vol. XXII., but in No. 25, Vol. XXII.]

PREPARATORY.

Q. 1. TESTING FOR GAS.—*Explain how you would use the safety-lamp in testing gas.*

Q. 2. VENTILATION.—*What is the effect of providing large air-ways and having the air travel at a low velocity?*

Q. 3. SHOT-FIRING.—*In what way is shot-firing dangerous in a mine containing inflammable gas?*

Q. 4. GEOLOGY.—*What is coal, and how may the constituents of coal be classified?*

SECOND CLASS.

Q. 5. COAL DUST.—*In what mines is coal dust most abundant? How is it formed?*

Q. 6. VENTILATION.—*About what proportion of the pressure spent on a ventilating current is used on friction and on giving velocity respectively?*

Q. 7. MECHANICS.—*What do you understand by the efficiency of a machine, lost work, useful work, and total work?*

Q. 8. BORING.—*What are the different purposes for which boring is used in mine operations?*

FIRST CLASS.

Q. 9. SINKING.—*What are the principal points to be considered before laying off shafts?*

Q. 10. PUMPING.—*What advantage is there in having a series of lifts in a shaft instead of a single lift to the surface?*

Q. 11. WINDING ENGINES.—*What kind of engines do you prefer for winding purposes, and why?*

Q. 12. SELF-ACTING TIPPLERS.—*Give a general description of some different forms of self-acting tipplers for emptying hutches.*

Best Answers Received to Questions in No. 21, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Siphons.

Q. 1.—*Describe the principle and action of the siphon.*

A.—The siphon is an appliance for removing water from a level to one lower over an intervening height. It consists of a series of pipes joined together, when completed being likened unto a long bent tube with one leg longer than the other. *See Figure.* At the end of the short tube or leg, such being the intake, a clack is fixed opening up over. At the other end a tap is in operation. A cup is fixed at the top of the bend which renders possible the complete filling of the pipes with water, thus excluding all air. An air-vessel is also connected to the same. When starting the siphon the tap at the delivery end is first closed. Water is then poured into the pipes by means of the cup. After the pipes are filled the tap at the delivery end is turned on. The water begins to flow through the pipes, and will continue to flow as long as there is water supply and all air is excluded from the pipes. On no consideration should air be allowed to gain admittance to the pipes; if it does so the necessary vacuum will be destroyed. In the case of a siphon, to render it efficient all joints should be made perfectly air-tight, the vertical drop should be so much greater than the vertical rise to render the overcoming of all friction due to the flow of the water in the pipes and the working of the clacks possible. The limit of working should not exceed 28 feet, and the length of flow should not be too great, otherwise the vacuum in the pipes will be broken and hinder the general working of the siphon.

The siphon depends upon the atmospheric pressure for its action. Water under a perfect vacuum may be raised nearly 34 feet. In practice this height is hardly ever attained, 28 feet being the practical limit. Therefore the vertical height from bend to delivery end should not exceed such amount. Again the atmosphere exerts a pressure of nearly 15lb. on everything it comes in contact with. Thus at the delivery end of the siphon there will be an upward pressure of nearly 15lb. per square inch, whilst the same pressure will be in force and acting in the same direction at the intake end. However, the pressure, termed the counteracting downward pressure, due to the water in the pipes will be different. Thus, partly due to this action and to the atmosphere, the water will be caused to flow. In the figure a siphon is shown removing water from a certain level to a place 8 feet below, over an intervening height of 20 feet from intake to bend. At the delivery end there will be a downward pressure due to the water in the pipes of $28 \times \cdot434 = 12\cdot15$lb. per square inch, and at the intake end $20 \times \cdot434 = 8\cdot68$lb. per square inch. As the upward pressure due to the atmosphere at both ends of the siphon will be the same, viz., about 15lb., there will be an effective upward pressure at the intake end of $12\cdot15 - 8\cdot68 =$

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

3·47lb., say 3½lb. per square inch. The motive column, viz., a column of water equal in height to the difference in vertical height from intake to bend and from delivery to bend, will be equal in pressure to the above, viz., 28 — 20 = 8 feet. 8 × ·434 = 3½lb. (nearly) per square inch. When the tap at the delivery end of the siphon is turned on the water immediately begins to flow out of the delivery side. As it flows it tends to create a vacuum, which is at once occupied by water from the intake side forced from the water supply to such position by the effective pressure above referred to.

To calculate the amount of water with which a siphon will deal, the following formulæ may be used :—

$$W = 4{\cdot}71 \times \sqrt{\frac{D^5 H}{L}}$$

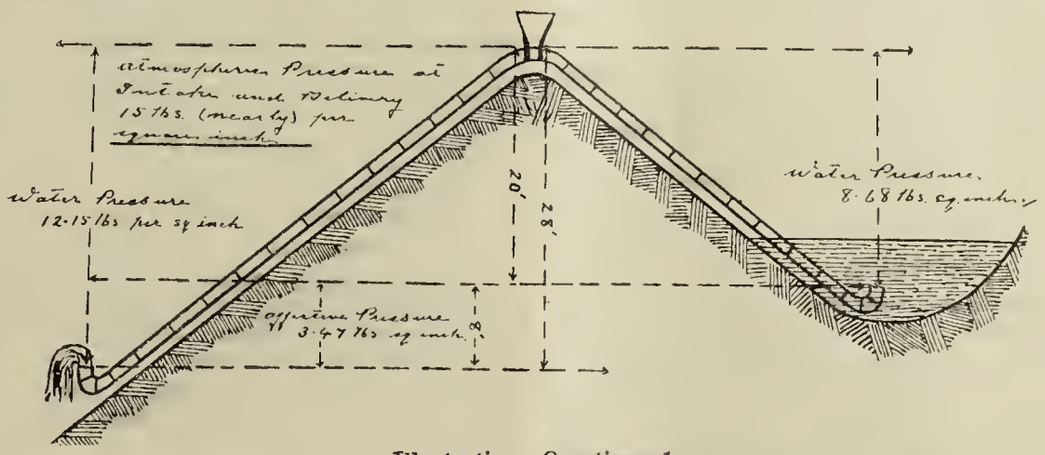
Where D = diameter of pipes in inches ;
H = head of water in feet ;
L = length of pipes in feet ;
W = cubic feet of water discharged per minute.

Head of water = 20 feet.

Assume the pipes are 4 inches in diameter and 400 feet in length. Then water discharged per minute =

$$4{\cdot}71 \times \sqrt{\frac{4^5 \times 20}{400}} = 33{\cdot}67 \text{ cubic feet.}$$

1 cubic foot of water = 6¼ gallons.
∴ gallons per minute = 33·67 × 6·25 = 204·437 gallons.


atmospheric Pressure at Intake and Delivery 15 lbs. (nearly) per square inch
Water Pressure 12·15 lbs per sq inch
20'
28'
Water Pressure 8·68 lbs. sq. inch
8'

Illustrating Question 1.

To secure efficient working a siphon should be well laid, provision being made for releasing the air at points where it is likely to collect. Unless provision is made a siphon will always need priming when it is required to be started. There are several devices that may be used to make the siphon self-acting. A float and lever may be fixed at the suction end. A good plan to prevent the admittance of air to the pipes is to have both ends submerged. Where there is not much difference of level between the intake and the delivery the ends of the pipes should be turned up. Under such conditions, when the supply falls below the level of the upturned pipe the water remains in, and when it again rises above it the siphon automatically starts. The pipes at the delivery end should never be larger than the supply pipes, otherwise the air is liable to enter and interfere with its working. It may even be an advantage to have the delivery pipes smaller. Should the water have a tendency to flow faster in the delivery side than in the suction, it would be advisable to have the pipe area restricted immediately near the end of delivery.

Helped by Prof. Boulton's *Practical Coal Mining*.

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E. Jones, F. Mitchard, G. Spinks, J. Brooks, T. E. Edwards, J. C. Rodman, J. Taylor, S. J. Jones, L. J. Thomas, G. A. Hyde, R. Brettell, J. Redfearn, E. Cobb, E. W. Williams, A. E. Helps, T. Hannan, J. H. Dakin, B. J. Noot, G. H. Fearn, R. Benson, W. Shore, J. H. Spence, W. Atherton, J. H. Moore, T. Gaskell, R. Wood, S. Beardsley, C. E. Morgan, E. R. Hindle, W. Booth, J. Morris, W. Williams, J. W. Brough (*12 marks each*).

T. G. Lippitt, W. C. Brooks, F. Barton, D. McBurnie, W. H. Holden (*8 marks each*).

Ventilation.

Q. 2.—*Which do you consider should be the larger, the main intake or return air-way, and why ?*

A.—In my opinion the return air-way should be larger than the intake, for the following reasons :—

During its passage through the mine the air expands in a varying degree owing to the warm state of the mine, and thus the air which passes along the intake will occupy a larger space in the return air-way. Expansion of the air takes place in all mines, excepting perhaps the very shallowest, owing to the temperature usually being much higher in the mine than on the surface, and the amount of expansion will be greater as the depth of the shaft increases. For example, suppose the temperature at the surface to be 60° and the mine temperature to be 90°—these are conditions which may and do often occur—then, by Charles' Law, which states that the volume of a gas varies as the absolute temperature, 100 cubic feet of air passing into the mine will occupy 106 cubic feet when it reaches the return air-way. Thus a smaller intake air-way will be required for a given quantity of air than the return air-way.

Another reason why the return air-way should be larger than the intake is that the volume of the air is increased in a greater or lesser degree by the gases given off from the coal and strata in the mine. We may take it that gases are given off in a varying degree in most mines and serve to increase the volume of the air by the time it reaches the return air-way. Cases have been recorded where the return air has been analysed and found to contain 2½ per cent. of fire-damp, all of which goes to increase the volume of the air passing along the return air-way as compared with the intake. Then in many mines the volume of the air is added to by blasting. In mines where blasting is carried on systematically and many shots are fired during the day the volume of the air may be increased to a large extent by the gases generated by the explosives. The increase in volume due to blasting may seem all the greater when we remember that a cubic inch of explosive may generate anything from 5,000 to 8,000 cubic inches of gas.

Then again, there is always a certain amount of leakage between the intake and the return which commences practically at the bottom of the downcast shaft, or at least from the first communication between the two, and this may be another reason for having a larger return air-way.

Thus we have the volume of the return air as compared with the intake increased by the higher temperature of the mine, the gases given off in the mine from the strata, and from the use of explosives ; therefore we must either make our return larger than the intake or have a greater velocity in the return air-current, which is not desired.

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[Note.—It is not so very long ago that there used to be an impression amongst old-fashioned colliery officials that the size of the return air-way was not of the first importance. It was thought that if the intakes were made and kept large enough for the air to go into the mine it would be able to find its way out no matter how small were the return air-ways. This idea seems almost too ridiculous to put on paper,

but, really, judging from the size of the return air-ways at some collieries it would appear that the same idea prevailed extensively amongst colliery managers—even at the present time. Now, seeing that as a rule the intake air-ways are also the haulage roads, these of necessity must be kept at something like a fair size, or we cannot get the coal out, consequently we find that the intake air-ways are kept fairly large, not because they are intakes, but because they are haulage roads. Return air-ways, on the other hand, not being as a rule haulage roads, are very often kept barely open, and nothing more; in fact, until it became law that all air-ways should be travelled at least once in every week, we were acquainted with air-ways along which no human being could travel, but upon which, for all that, the ventilation of districts depended. Of course, theoretically speaking, if we are to maintain the same velocity in the one air-way as the other, the return must be slightly the larger to allow for the increased volume due to the generally higher temperature, but we must not overlook the fact that there would be no increase of weight due to the increase in temperature. There would, of course, be an increase in volume due to the taking up of the gases made underground, and this would increase both the volume and the weight of air passing through the return. Summing up, we might say that if the intake air-way was considered just large enough for the volume passing, then the return air-way should be slightly larger, but if the intake air-way was considered amply large then the return would not need to be any larger. It would be ridiculous to think that, if we enlarged our intake air-way to allow of endless rope haulage instead of direct-acting, we must therefore enlarge our return in order to keep it larger than our intake.—C.C.M.]

W. Williams, T. Gaskell, B. J. Noot, J. H. Dakin, D. McBurnie, J. C. Rodman, J. Taylor, C. Simpson (*12 marks each*).

S. J. Jones, J. Brooks, E. Cobb, G. H. Fearn, W. Shore, F. Mitchard, G. Bosher (*8 marks each*).

W. C. Brooks, R. Brettell, A. Parry, W. J. Richards (*4 marks each*).

Shot-Firing.

Q. 3.—*Briefly describe two methods of firing shots. Which do you prefer, and why?*

A.—The methods of firing shots which I will endeavour to describe are (1) the electrical method, and (2) the method of firing them with safety fuse.

Shot-firing by Electricity.—Firing shots by electricity may be on the low tension or high tension system. In connection with both systems the necessary apparatus is a battery, or otherwise an electrical machine for generating and supplying the current, also the cable and wires to connect the charge to the battery and the detonator, which may be either a high or a low tension fuse. These two kinds of electrical fuses are similar in appearance, but differ in construction. When using high tension fuses a very small current of electricity at a high pressure is necessary, whereas low tension fuses require a large current at low pressure.

The detonators consist of a mixture of fulminate of mercury and chlorate of potassium in both the high and low tension fuses, the method of firing them being the same. The method of firing them by electricity is as follows:—

The detonator is inserted carefully into the charge, which is pushed gently to the far end of the shot-hole, and the two copper detonator wires allowed to project a few inches out of the shot-hole. Having stemmed the hole the wires are connected to the cable and the electrical battery. The battery is then brought into operation by turning a handle and pressing a push-button, thus firing the charge.

Shot Firing by the Safety Fuse.—When firing explosives with the ordinary safety fuse, it is customary to cut off the end of the fuse in an oblique or slanting fashion previous to inserting it into the detonator. Let it be understood that the detonators to be used are similar in composition to the high tension and low tension detonators, only that they are hollow at one end for the reception of the safety fuse.

The safety-fuse being cut the required length it is inserted into the detonator, the open end being ripped by pliers so as to hold the detonator on to it firmly. The detonator is then pushed into the charge in the usual way, and also into the shot-hole, with the safety-fuse projecting from the hole a certain length as required. The stemming is then applied in the usual way, and the end of the fuse lighted by an open light, or by an igniter fuse such as "Bickford's," thus firing the charge.

My preference is in favour of the electrical method of shot-firing for the appended reasons:—

The chief object of electrical shot-firing in my opinion, is to ensure greater safety to the workmen doing the shot-firing, and to those employed in the mine generally. Firing shots by electricity tends to bring about a general reduction of the various risks attending blasting operations in the mine, because the shot-firing is not attended with exposed flame and sparks so manifest when firing with safety fuse, thus there is less liability of ignitions of fire-damp. Electrical shot-firing does not produce the same amount of smoke and fumes as that which originates, or is produced, by safety-fuse, and no naked lights are required as usual where safety-fuse is being used.

In addition, electrical shot-firing does away with premature shots and hang-fire shots. There is less liability of miss-shots occurring, and even should one happen the workmen can go to the shot almost immediately, if desired.

Firing shots by electricity enables any number of shots to be fired simultaneously, this being advantageous, especially in shaft sinking, as the stone is supposed to be broken up better with the shots being fired all at once. Not merely so, but it enables the men to be brought to the surface before the cable is connected to the electrical battery. There is no risk upon descending the shaft even should all the charges not have been exploded, there being no possibility of hang-fire.

In conclusion, electrical shot-firing is advantageous under all circumstances, as it enables the blasting to be done more quickly and with better results. It has also been the means of bringing about greater safety, especially in gaseous and dry and dusty mines. It also meets the requirements of the C.M.R.A.

Special Rule 72*a* in force in the Wigan district states:—

"Where permitted explosives are required by law they shall be fired by electricity."

Assisted slightly by Cochin's *Coal Mining*.

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G. H. Fearn, W. Booth, S. Beardsley, J. H. Spence, W. Williams, J. W. Brough, A. Champkins, R. Brettell, D. McBurnie J. C. Rodman, G. Herbert Fox, L. J. Thomas, G. A. Hyde, C. Simpson (*12 marks each*).

T. E. Edwards, F. Mitchard, J. Brooks, W. C. Brooks, J. Taylor, T. Hannan, W. H. Holden (*8 marks each*).

Safety Lamps.

Q. 4.—*Describe the construction of a safety lamp of which you approve. Give your reasons for approving of it.*

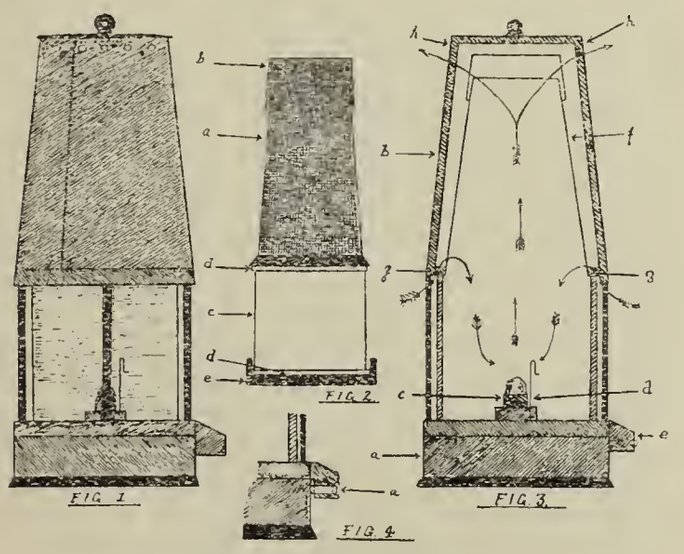
A.—As a preliminary it will be understood that the safety-lamp is an illuminating appliance which renders possible the mining of coal in places where inflammable gas is prevalent. Before its invention great risks were run by having naked lights for illumination in suspected places. Now mining can be carried on in comparative safety by means of the safety-lamp, because under proper working conditions it is impossible for outside gas to be ignited with the flame necessary for illumination.

There are many different types of safety-lamp, but all may be said to be modifications of those first patented.

In every safety-lamp the gauze is the principal part. It consists of a net-work of very fine iron wire, one-fiftieth of an inch in thickness having twenty-eight lines or rather wires to the lineal inch. Thus in a square inch of gauze there are $28 \times 28 = 784$ apertures. Every safety-lamp gauze is more or less cylindrical in shape, and to ensure further safety is surmounted by a smaller gauze, termed a "cap." In some safety-lamps the gauzes are doubled or trebled. When properly put together the only admittance of air to the flame of the safety-lamp is by way of the gauze, and the products of combustion also pass through it. We know that flame consists of gases at a white heat, therefore the iron wires being of a lower temperature than that of flame and the gauze being so constructed as to retain that lower temperature, proper working conditions always being maintained, neither the flame of the lamp nor the gases that may ignite inside the gauze can pass through with

sufficient heat to ignite the outside gas. Yet the idea must not be harboured that the safety-lamp is always safe in explosive mixtures. Every lamp is unsafe under such conditions, because the extra heat imparted to the gauze due to the prevalent inflammable gases will increase its temperature to such an extent that it will not retain its cooling effect in respect to the flame. Thus it would be possible for flame to pass through the gauze and cause an explosion by igniting the outside gas.

The two chief considerations in respect to safety-lamps are (*a*) safety, and (*b*) illumination. Where one type of lamp may be superior in one of the above respects it may be inferior in the other respect. For instance, as regards the Davy, it is certainly safer than the Clanny in dangerous mixtures, but it is behind as an illuminating means. Again a Hepplewhite-Gray may be better than the Clanny for gas-testing, and even in illumination, but for general use in the mine the Clanny holds the advantage, because it is simpler in construction and can be better examined internally and externally. I approve of all safety-lamps, and for general use in the mine favour the Clanny, not because it is in all respects superior to others, but because I have had a good experience with the same and have not yet found it to be non-efficient.



Illustrating Question 4.

Figure 1 is a general view of the lamp, *Figure 2* the inside construction, and *Figure 3* a view of all the different parts fixed into position. The fresh air enters the lamp by way of the inlet air-holes placed under the rim of the bonnet, then passes through the bottom section of the gauze cylinder to the lamp flame. From the flame the air passes up the centre of the lamp, through the top part of gauze and gauze cap, and then through the outlet air-holes under the bonnet cover. By reference to the arrows in *Figure 3* the direction of air-current will be seen. As stated, the principal parts of the lamp are the bonnet, the oil-vessel, and the inside construction shown in *Figure 2*. At (*a*) the gauze is shown, at (*b*) the gauze-cap, at (*c*) the glass cylinder, at (*d*) the necessary asbestos washers for keeping the lamp when fixed into position air-tight except by way of the gauze, and at (*e*) the lamp-ring. The top of the gauze rim fixes under the bonnet rim. Therefore on the ring being screwed into position it tightens up the glass, &c., so that air cannot gain admittance except by way of the gauze. The oil-vessel is next screwed into position, which is attained when it comes in contact with the lamp-ring. All the parts will be seen fixed into position by reference to *Figure 3*. (*a*) shows the oil-vessel, (*b*) the bonnet, (*c*) the wick pipe, &c., (*d*) the pricker necessary for adjusting the wick when occasion requires it, (*e*) the lock, (*f*) the gauze, (*g*) the air inlet, and (*h*) the outlet air-holes. The locking arrangements will be seen in *Figure 4*, consisting of an ordinary tightening screw, which is screwed up against the oil-vessel by means of a key. Only authorised persons are allowed to carry such keys, and they must not on any consideration unlock lamps unless the conditions are in accordance with the mine regulations.

Reasons for approval of the above type of Safety-Lamp.—(1) Simple in construction. (2) Light. (3) Good illumination. (4) Good gas-detector. (5) Good locking arrangements.

It must be understood that the above advantageous conditions are secured when the lamp is compared with certain others. With an ordinary Clanny an experienced miner can detect as low as 2 per cent. of fire-damp, therefore the lamp is suitable for the workmen, because a working place is not deemed dangerous should the gas be below 2½ per cent. (New Mines Act), that is sufficiently dangerous for the workmen to be withdrawn. Again when properly locked and no tampering with the same is indulged in the oil-vessel will never become loose, as it is impossible for the screw forming the lock to slip when in proper working order. For examining purposes previous to being taken into the mine the Clanny is one of the best. The examiner when making an external examination can see all the chief parts. Thus it is practically impossible for a defective lamp to pass the examiner. For general underground use the Clanny has no superior under proper working conditions. For detecting low percentages of gas previous to the firing of shots, shot-firers could be supplied with some special means of detection.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

W. Heaton, J. Redfearn, J. C. Rodman, T. E. Edwards, R. Benson, W. Atherton, T. Gaskell, R. Wood, W. Williams (*12 marks each*).

W. Shore, D. McBurnie, J. Brooks, W. C. Brooks, L. J. Thomas, J. Taylor (*8 marks each*).

SECOND CLASS.

Ventilation.

Q. 5.—*What circumstances would guide you in determining the quantity of air necessary for the ventilation of a mine?*

A.—The circumstances that would guide me in determining the quantity or volume of air necessary for the ventilation of a mine would be: (1) Whether a fiery or non-fiery mine; (2) the amount of gas given off; (3) the number of men and animals employed therein; (4) thickness of seam, as this would influence the method of working adopted; (5) the extent of goaf edge to ventilate and the sanitary condition of the mine; (6) the extent and condition or efficiency of conduction through the workings of the same.

It is of vital importance that these matters should be carefully considered as they greatly influence the volume of air required for the ventilation of a mine. It is obvious, though, that the volume of air required in mines depends on conditions which vary considerably in different mines. The number of men and horses alone can only give an approximate idea of the amount of air required in any mine. We know that General Rule 1 of the C.M.R.A. requires an adequate amount of ventilation to be kept constantly travelling in every mine to dilute and render harmless noxious gases to such an extent that the working places of the shafts, levels, stables and workings of the mine, and the travelling roads to and from those working places, shall be in a fit state for working and passing therein. In some countries we find the mining laws fixing the minimum quantity of air per minute in cubic feet for each and every person employed in a mine. For example, the Anthracite Mine Law for Pennsylvania states that the minimum quantity of air shall not be less than 200 cubic feet per minute for each and every person employed in a mine, and as much more as the circumstances may require. In the Bituminous Mine Law of the same State, 100 cubic feet per man per minute is required, but in every mine where CH_4 has been detected this amount is increased to 150 cubic feet per man per minute. Other mining laws specify similar amounts. The Prussian Royal Commission reports:—In all cases the volume of fresh air must amount to at least 70·62 cubic feet per head of the maximum number of workmen employed below ground in the course of one shift. In these calculations a horse is reckoned as equivalent to four men. The New South Wales C.M.A. requires not less than 100 cubic feet per minute for each man, boy, and horse employed in the mine, and not more than 70 persons may be employed in one split. In Belgium the quantity prescribed by law is from 70 cubic feet per minute per ton of coal worked. But truly speaking if the ventilation of a mine must be planned so as to be in every respect adequate, the volume of fresh air introduced into the pit must be at the very least sufficient to neutralise the worst imaginable fouling

of the actual pit air which can happen in the several working places in the course of one working shift. In so much as this fouling of the air results from the breathing of men and horses, from the burning of lights, and from such shot-firing as may take place, the calculation of the needful quantity of fresh air may be based simply on the greatest number of men and horses present in the pit at one time. This method of calculating, however, is otherwise complicated, when other considerations intervene—such as lowering the temperature in the pit, dealing with chemical processes like the dry fungus and rotting of timber, the formation of CO_2 or decomposition of pyrites or coal basses, and more especially the prevention of CH_4 accumulations. Thus it is obvious that in such cases it would hardly be correct to reckon only the number of workpersons and horses employed as a standard of measurement, and plan the total air supply in accordance therewith. Since in fiery mines the issue of dangerous gases far exceeds all other contributory causes of the fouling of the air, the ventilation of such mines should be proportional to a certain extent on the more or less considerable issue of gas known to take place therein. This in turn will depend on the newly-bared working faces, the amount of coal won within a given interval of time, and the CH_4 and CO_2 contained in the return air-current. These items form a sound basis of calculation for measuring the issue of gases. I know several firms who base their quantity of air required on the principle of the quantity of gas given off and the extent and efficiency of conduction of the air through the workings, and simply define it a fiery or non-fiery mine. They then base their calculation on the idea that for a non-fiery mine 150 to 250 cubic feet per man per minute is sufficient, whereas in fiery mines 250 to 500 cubic feet per man per minute is considered sufficient. In this method of procedure they will be governed by the extent of the workings and the area of the air-ways through which such will traverse; because chiefly of keeping down the velocity in a fiery mine. One mine whose workings are not far from the pit bottom may be better ventilated with 200 cubic feet per man per minute than another with 500 or 600 cubic feet. Thus we see that no hard and fast rule can be laid down for a case of this sort. It all depends on circumstances. I consider it best to assume a fair velocity for the air to travel at, when we work on the principle of the quantity depending on the amount of gas given off. The velocity of the air travelling along a face in a fiery mine where unshielded lamps are in vogue should never be less than 120 to 150 feet, nor more than 350 feet per minute. In ordinary circumstances the velocity along the face should be from 2 to 3·5 feet per second, in splits 3·5 to 5 feet per second, in main air-ways 5 to 10 feet per second, and in shafts it often reaches 20 to 40 feet per second. Then the quantity of air will be proportional to the area of the air-ways which in fiery mines must be large; then no difficulty will be encountered in circulating the necessary quantity of air, independant of the number of men employed, especially if we keep the quantity of CH_4 in the return below 1·5 per cent.

Partly indebted to *Modern Mining Practice*, vol 1, pp. 170.

JAS. GRUNDY, Wigan Road, Bryn.

[NOTE.—As we have often said, in determining the quantity of air necessary for a mine we can only judge by the conditions; it is absurd to attempt to lay down a rule such as so many cubic feet per man, three times as much per horse, and so on. It is equally futile to attempt to base the quantity required on the amonut of coal sent out, or the length of coal face open, and on any such method. We must have sufficient ventilation to dilute all blowers of gas at the point of issue, and to keep away all accumulations of gas. We must have sufficient air to render the presence of gas undetectable, either in the faces or returns, by the flame of a safety-lamp. Under the new Act coming into force on the 1st of July, 1912, we must have so much air sent through the mines that the percentage of oxygen present shall never fall below 19, nor the percentage of carbon dioxide present rise above one and a quarter. Intake air-ways are not to be considered "normally kept free from inflammable gas if the average percentage . . . . exceeds one quarter."—C.C.M.]

E. Ambrose, A. Nelson, J. A. Withington (*12 marks each*).

J. Taylor, A. Stephens (*8 marks each*).

Haulage Roads.

Q. 6.—*Assuming that a large number of accidents occur on underground haulage roads, what precautions and rules do you consider necessary to insure the safety of persons working and travelling on these roads?*

A.—The committee appointed by the Royal Commission on Mines reported that the accident percentages for the decennial period 1898–1907, were:—Breakages of ropes and chains, 7·0; running over or crushing by tubs, 65·5; other haulage accidents, 27·5. It was generally admitted, other things being equal, and where the conditions are favourable to it, that haulage which allows of a slow rate of travel and regular feed to the shaft bottom or to the screens, is more conducive to safety to persons having occasion to work and travel upon such roads, than a haulage system with a high speed and producing a spasmodic feed of full tubs at the shaft bottom.

Seeing that no particular system of haulage is mentioned in the question, it must be taken in a general manner, but it should be mentioned here that the selection of suitable switches and other safety appliances and their position on the plane can only be properly made when the haulage arrangement in vogue is known, together with the inclination of the plane. There should be a path along the side of the road, *i.e.*, if it is used as a travelling way, with a width of not less than three feet from the rails; this would be in addition, of course, to the refuge holes as required by law. It will admittedly be difficult to maintain such a state of conditions in cases of bad roof, especially if endless rope is employed, but where the character of the strata admits of this width, advantage should be taken of it and it should be kept in proper repair. I understand that in some districts workmen are not permitted to travel on a haulage road while the rope is in motion. This is a wise precaution and should, in my opinion, be made general, especially in fast haulages, because a space of two feet would not be sufficient to protect a person when a derailment of the "set" occurred. Naturally this danger is greatly mitigated in cases of slow and continuous haulages, but even under such conditions derailment is attended with danger, moreso if the road is supported by timbering, because the "arms" usually project from the sides and are often knocked out and bring about a fall of roof should a tram become derailed. All haulage roads should be constructed as straight as possible, as a tortuous road is conducive to accidents. Attention should also be paid to the manner in which the rails are laid. They should be of the T-headed type, and efficiently "chaired" and "fished," these precautions will ensure protection against the joints becoming loose. A point which is now becoming more generally recognised for the safety of the persons handling the tubs is the necessity of ample space at the junctions, &c., where the trams are coupled on to the main rope. The man-holes as required by General Rules 14 and 15 should be made at intervals of not less than 20 yards apart, and all should be on the same side of the road, and on the same side as the above-mentioned pathway. The side of the plane so selected should be that which affords the greater protection against the swinging of the rope, &c., so common in some haulage planes. The dimensions of these man-holes should be ample—five feet high and four feet wide is a common size—but the width should not exceed about three or four feet, as otherwise a runaway tram would have sufficient room to enter and possibly injure the men inside. It is unnecessary to state that these holes must constantly be kept clear and free from obstructions, such as timber, &c. Electric cables and signalling wires should, in case they are required to pass man-hole entrances, be conducted either on the ground level or near the roof, otherwise they may impede a hasty entrance in emergency. The persons employed for handling and coupling on the tubs at the various shunts should be carefully protected. The hands are usually the first to get damaged, therefore some guard is recommended.

On endless rope inclines an efficient means of connection is imperative, and to provide for them I should use chains from 10 to 12 feet in length for connecting the tubs to the rope. Each chain is provided with a hook at each end; one of these is fixed to the tram and the other end passed three times round the rope, and finally secured by the hook. As a means of attaching and detaching the tubs this arrangement is inferior to others, but it is superior when the power upon the rope is considered, which is very essential on steep gradients. Run-

away switches and "stop blocks" should be used according to local conditions. The latter are suitable at the junctions so as to hold the trams until they are ready to be connected to the rope. The switches—of which there are numerous forms—are fixed at intervals along the main plane, so that in case any tram or set of trams runs "wild," they can be arrested before gaining much speed. All my couplings if required for connecting a train of trams together would be of the loose type, carefully tested, examined at specified intervals, and annealed periodically. A very frequent source of accident here in South Wales is the breakage of couplings or tram shackles. This has somewhat been alleviated by arranging with the attendant the payment of a certain sum for the detection of each defective coupling; under such conditions the couplings are never in need of inspection.

To prevent a tub from parting with the remainder of the set in the event of a coupling breaking, bridle or over-chains are frequently employed. These are recommended when the workmen are being conveyed to and from their working places. A sufficient number of "cockers" or "sprags" should be provided at the shunts for retarding the trams when required. The rope should receive as much attention as if it was a winding rope. It should be thoroughly tarred or greased at regular intervals with a view to preserving it. It is a common practice at some mines to systematically re-cap haulage ropes at stated periods. With regard to the attachment of the trams to the rope, underneath attachment induces steadiness to the moving tubs, but unless the "clip" is worked from the top of the tub there is the danger of those engaged in fastening the tubs to the rope getting injured. A device sometimes employed for preventing tubs running back is a self-acting tub stopper, which, if a tub should run back, holds it by the axle. Another point worthy of care is to see that the tubs in the shunts are not pushed on to the main haulage road before a proper connection is made. As a preventive many devices have been tried. A simple plan is to fix a bar across the entrance of the incline, and the tram turned on the flat plates and connected to the rope before the obstruction is removed. The following are a few rules I should have enforced:—

(1) Riding on trams should, except in certain cases, be strictly prohibited, and notices to this effect posted up at every junction and double parting.

(2) All possible obstructions should be removed from the haulage planes, and the refuge places should be maintained in such condition as to properly comply with the C.M.R.A.

(3) All mechanical appliances as mentioned above must receive proper care, and be examined at least once a day. These inspections should extend to (*a*) provision of "drags" for prevention of runaways; (*b*) the installation and use of the signalling system; (*c*) maintenance of roads of ample size, with special attention upon the pathway, if any; and (*d*) proper inspection and greasing of haulage rope and couplings and the bridle chains.

(4) Should any timber be displaced due to runaways the same must be re-set before the plane is again employed for conveying workmen.

(5) All electric cables for power purposes should be well protected, either by suspending them out of reach of the persons passing, or conducting them in boxes provided with prepared troughs and covered up with pitch.

(6) No repairers should be allowed to work upon the plane unless the superior deems it safe or unless they happen to work when the haulage is at rest.

(7) The C.M.R.A. should receive attention and respect at all times, and all persons employed directly or indirectly with the haulage system should make it a point to obey the rules in connection with their duty.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[NOTE.—There will always be danger in travelling along haulage roads when the haulage is in motion. Personally we think the endless rope system of haulage is more dangerous to persons travelling than any other kind. For one reason seeing that we have to maintain two roads it is not possible to allow room for a person to travel along the side, as the width would then be too great to maintain. In the case of direct or main and tail haulage it is possible generally to maintain width at the side for travelling, and this greatly adds to the safety of travelling. When the road undulates the ropes themselves become a source of danger owing to their tendency to fly up towards the roof in certain places. To avoid danger to persons travelling in haulage roads we should not allow any except officials and persons specially authorised to travel endless rope haulages when in motion. We should thus reduce the number of persons exposed to danger on these roads to the least possible number. Each set of trams or tubs should be provided with a trailer to prevent ascending journeys from running away downhill in case of a breakaway.

In the case of main and tail or direct-acting haulage we should maintain a space of at least a yard on the side of the road all the way, and should also provide each ascending journey with a trailer. Our rules with regard to the provision of manholes would be the same as those of the C.M.R.A.—C.C.M.]

W. A. Onley, J. Grundy, E. Ambrose, A. Stephens (*12 marks each*).

Shaft Pillars.

Q. 7.—*In determining the size of a shaft pillar what effect will the depth of the shaft and the inclination of the seam have?*

A.—The function of a shaft pillar is to support or keep intact the strata around the shaft. This pillar usually takes the form of a circle, by leaving a certain area of the coal seam unworked, except naturally those drivages necessary for the sidings, airways, &c. If no pillar was left or if the pillar left was too small, there would be a danger of the subsequent disturbances of the strata resulting possibly in serious and expensive damage to the buildings erected upon the surface, and to the shaft linings and fittings. Consequently the pillar should be so dimensioned as to prevent the "draw" of the subsiding strata affecting the shaft, and therefore dependent to a great extent upon the depth of the shaft. Similarly the pillar will depend, although to a lesser degree, upon the inclination of the same, and also its thickness. By working the coal completely away from under a shaft we deprive the strata above of their basal support. The result is that these beds subside, the amount of subsidence depending upon the efficiency of the packing, and the nature of the material employed, that is whether the packs are as solid as the coal originally there, or more or less loose, which is often the case. An ideal pack as described in the former case cannot be realised in practice. The subsidence may or may not reach to the surface, according to the depth of the shaft, and the extent of the extracted coal. The magnitude of a pillar is governed by several circumstances: (1) The depth from the surface is of great importance; (2) the nature and thickness of the overlying rocks; (3) nature of roof and thill of seam; (4) thickness and hardness of seam, *i.e.*, whether soft and yielding or hard and compact. The position of the shaft pillar with respect to the shaft itself varies according to the direction and rate of inclination of the coal seam. In cases where the coal seam is comparatively flat the site of the shaft is in the centre of the pillar. In case where an inclined seam of coal is worked the conditions are considerably altered. In such strata it is an acknowledged fact that the subsequent fracture has a tendency to break in a direction at right angles to the planes of bedding. Mr. Callon advocated this theory, which is known as the *theory of the normal*, and upheld it in his mining lectures. Of late this theory has not been found to be wholly true; the general line of fracture, although locally taking place at right angles to the stratification, is alternated with a parting of rending of the rock along a bedding plane, and the result is that a series of inverted steps are formed thereby forming a dome-shaped fracture. According to Mr. Fayol—"In stratified deposits the zone of subsidence is limited by a dome-shaped figure having for its base the area excavated, the extent of the movement diminishing the farther one departs from the centre of the area." Mr. Fayol is a great authority in this particular subject, and supported his conclusions and deductions not only by observations conducted in mines, but also by means of an ingenious series of models, representing and demonstrating the effects on a reduced scale, the subsidences in strata caused by the removal of the coal. These models consisted of wooden boxes having a glass front, and to represent the removal of a coal seam a stratum composed of thin strips of wood was withdrawn from the bottom of the box. The

strata were represented by layers of sand earth, clay, &c., varying from $\frac{1}{24}$-inch upwards.

With regard to the influence of the inclination of a seam upon the shaft pillar, Mr. Fayol experimented in a similar manner to the above but with inclined strata; he arrived at the conclusion that the axis of the resultant dome was vertical for horizontal, and inclined between the normal and the vertical for inclined seams. In *Figure 1* is shown the probable subsidence of strata caused by the extraction of a portion of an inclined seam of coal. It shows diagrammatically the dome-shaped line of fracture resulting. As would be anticipated the initial direction of the line of break occurs along a line lying between the vertical and the normal to the planes of cleavage. As the area of the excavation (*i.e.*, the base of the dome-shaped fracture) extends, the dome of broken rocks gradually ascends, until in time a point is reached whereby the surface is damaged. We are able to deduce from these observations and experiments a rule for determining the position of the shaft with regard to the shaft pillar when the seam is highly inclined. In *Figure 2* are shown the probable directions of the breaks, namely, *FA*, *EB*, *GH*, on each side of the shaft pillar *AB*. It appears that the shaft must be sunk nearer *A* than *B*, so as to enable it to be at an equal distance from the lines of fracture. A good arrangement is that whereby the minimum radius of pillar as calculated for a flat seam is allowed to the dip and strike sides of the shaft, but with regard to the rise side the pillar may be calculated by drawing from the shaft mouth a line perpendicular to the seam, as *CB* in *Figure 2*. When this cuts the coal seam that point should be the upper end of the pillar.

Assisted by Boulton's *Practical Coal Mining*, pages 299—302.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

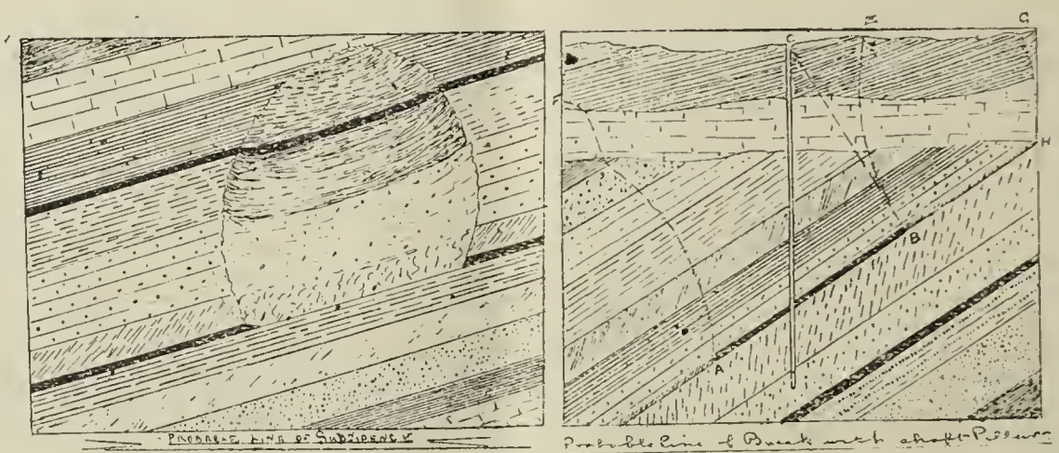
[Note.—We have been reading to-day an extract from a paper by one of H.M.I.M., in which he explains that it is quite possible to work away the whole of the coal surrounding a pit shaft without injury to it. We very much doubt whether he will be able to carry many mining engineers along with him. Working out the coal undoubtedly affects the surface over a greater area than that of the coal worked, and although possibly the effect of working a seam 600 yards deep is not so severe as in the case of a seam 300 yards deep, of equal thickness, still the effect is probably felt over a greater area. Consequently, it is necessary to leave larger pillars in the deeper seams. The inclination of the seam has also an important bearing on the shaft pillar, but more with regard to its position than its size. Where the seam is inclined it is necessary or certainly advisable to leave the larger portion of the pillar to the higher side of the shaft. Of course, in perfectly flat seams the shafts should be in the centre of the pillar.—C.C.M.]

W. A. Onley, E. Ambrose, J. Grundy, A. Stephens, J. A. Withington, J. Cannon, J. Taylor (*12 marks each*).

Ropes.

Q. 8.—*What are winding and haulage ropes made of, and what regulations for their preservation are necessary in the interests of safety and economy?*

A.—Winding and haulage ropes of the present day in use in Great Britain are made chiefly from various grades of steel, usually designated in an arbitrary and somewhat misleading fashion. Such terms as improved patent crucible, best patent crucible, mild, best, and improved plough, are used by many makers, but not as denoting any exact standard of tensile strength. The fundamental difference between so-called "crucible" steel and "plough" steel, is that the iron bases used in their manufacture are not the same. Plough steel is made from a base or standard of the finest quality, and crucible steel from some cheaper or more inferior iron. Other differences between "crucible" and "plough" steels are the outcome of manufacture; for example, the heat treatment and the number of passes through the dies. We find from the several qualities of steel used that plough steel has the highest tensile strength, 110 to 120 tons per square inch, and Bessemer or mild steel, the lowest, 40 to 45 tons per square inch. As regards the types they are constructed under, they may be either of Ordinary Lay, Lang's Lay, or Locked Coil, the two chief types constructed being the latter two. These are most frequently used for winding purposes, the Locked Coil giving very excellent results for winding in sinking pits. For hauling purposes we find the Ordinary Lay and Lang's Lay most generally employed.



Illustrating Question 7.

In regard to the regulations for the preservation of the same in the interests of safety and economy, it is well in the first place to select a rope of good material and of sufficient strength to enable the work to be carried out with a maximum amount of safety, thus economising in the long run. Then for further economy and safety we should see that any type of rope is cared for before, as well as after, it is put into use. Then further regulations can be divided under four main heads:—(1) Storage of ropes; (2) lubrication; (3) prevention of undue strains; (4) examination and cleaning. In regard to head (1), if any rope was kept in stock for any period prior to putting it in practical operation it should be kept in a dry place, raised from the floor, and of course well lubricated before storing by a non-acid lubricant being kept covered over with a water-proof sheet to prevent moisture, &c., getting to the interstices of the rope and causing corrosion, oxidation, and rust. The same should also be kept on a proper rope reel, so that when laid on at the pit kinking would be avoided. It is an acknowledged fact that when a rope becomes kinked its efficiency is considerably reduced, having a tendency to shorten the life of any type of rope. Respecting (2) it is essential that every rope should be sufficiently lubricated with a lubricant of a non-corrosive character at least once a week. In regard to winding ropes, in cases of wet shafts where the water is acidulous, and also in upcast furnace shafts, this operation requires to be performed more frequently. (3) We all, I am sure, understand that the

strains which winding and haulage ropes are subjected to are in many instances very excessive indeed. Probably the thing which exercises the most detrimental effect on the life of a winding rope is the jerking it receives when lifting the cage off the catches or keps, either at the top or the bottom. It is obvious that, if sufficient slack rope was given and the winder started the engines off as roughly as possible, most of the ropes would snap off, or providing we had only a few inches of slack rope a rough start would double and treble the strain. Thus we find that, if we would combine safety with economy, it is essential that we should avoid such jerking and also have a high factor of safety. There are various items, however, that may be considered with a view to reducing the strains and wear and tear of ropes. In the case of hauling ropes sufficient pulleys of suitable size should be provided where the rope is likely to trail and the same should be kept clean and oiled. The angle the rope makes from the drums either in hauling or winding to the pulleys, particularly so in winding, is an important factor and should be as large as possible. All drums and pulleys should have a minimum diameter of 120 times the diameter of the rope. In winding the amount of side travel at the drum should be reduced to a minimum. It is easy to understand that the greatest strain a winding rope is subjected to is at the commencement of the wind, due to the fact that we have not only great loads to lift but in deep winding the speed of such loads has to be accelerated to a maximum in the least possible time. This brings us to the various devices that have been brought forward with a view to minimising the shock to the rope at the beginning of the wind. To counteract this particular evil we may employ rubber and spring cushions under the pulley pedestals on the headgear. Another method is to have springs at the bottom of the shaft, the cage resting upon them whilst loading and unloading. It is defined that they assist greatly in overcoming the inertia of the lift. Springs may also be introduced in the bridle chains with the same object.

We must not forget that these devices have certain disadvantages, the greatest being that both rubber and springs lose their elasticity owing to the continual varying strains to which they are subjected. Hence we see that it is necessary that every care should be exercised to avoid jerking, and the first duty in this respect rests entirely with the engineman, because above all the chief factor governing the undue strains of winding ropes is the manner in which the engine-winder handles the engines. Thus if we prevent jerking at the first we can neglect the adoption of springs, &c., as they are not very much use in saving the rope. In respect to head (4) we are guided to a certain extent by the C.M.R.A., but irrespective of such a daily examination and cleaning of ropes is an absolute necessity to be consistent with safety, especially so in winding ropes. A method generally adopted is to allow the rope to pass slowly through the hands of an appointed examiner, who is provided with thick gloves. The appointed examiner for the winding rope is generally the browman, and for haulage ropes the underground pusher-on, or ropeman as he is sometimes termed. By the aforementioned examination any unevenness and broken wires may be easily discovered. To perform the operation thoroughly the rope should be kept clean by one or other of the numerous devices which have been devised for this particular purpose, the principal being to pass the rope through a box containing revolving brushes or scrapers. It is a good practice when examining ropes to pay special attention to the cappings, and that portion immediately about them, and also the portions in contact with the pulleys. It is well to pay special attention to the ropes when running on and off the drum so that any pinching may be located. The last but not least point to be considered is to periodically re-cap ropes, especially winding ropes, so that a fresh portion of the rope is brought to bear on the headgear pulleys when the cages are resting at meetings and also when decking. Of course, re-capping has another important object, *i.e.*, the portion of the rope adjacent to the cap which is so much subjected to vibration, and whereby the nature of the wire is changed from a fibrous character to that of a crystalline, is periodically removed.

In conclusion I might state that, if an old rope has worn a false groove in a pulley, the new rope should not be put on until the sharp edge where the false joins the original groove has been turned to its former shape, and the false groove itself made the proper size. No matter of what quality the ropes may be, or of what type they are constructed, they should have a factor of safety of ten and eight respectively, *i.e.*, the breaking strain of the winding rope must be ten times its safe working load, and the breaking strain of the hauling rope must be eight times its safe working load.

Slightly indebted to BOULTON's *Practical Coal Mining* (vol. 3).

JAS. GRUNDY, Wigan Road, Bryn.

E. Ambrose, A. Nelson, A. Stephens, J. Taylor (*12 marks each*).

FIRST CLASS.

Squeeze.

Q. 9.—*In case a squeeze occurs in a mine of which you have charge, endangering a heading and threatening to shut off part of the work, how would you proceed to stop its progress?*

A.—In anticipation of such a thing happening I should always keep the packs drawn up as close to the face as practicable, and chocks set in the waste, the sides of the road being further strengthened with soft wood chocks set at equal distances alternately on each side of the road and filled up solid with dirt.

During the squeeze I should withdraw the men, and, with the aid of some experienced timbermen, commence to "middle set" or "jack leg" all the bars at the face, starting from the "dip" or "lower" side first. Having done this, I should, if I thought it necessary, put up additional chocks as I deemed fit, and then commence setting props down the centre of the road, if it was not barred; if it was barred, "middle setting" the bars. The idea for this timber setting is not to set the timber extraordinarily tight so as to form a very rigid support, but to form a support firm, but still capable of yielding slightly to the great pressure which cannot be stopped directly, and which only breaks the timber if set as described first. For this purpose tapered timber is excellent, as it allows the weight to be gradually taken by the prop without breaking it, or forcing it up into the roof. Having done this, I should fence the road off at sufficient distance from the danger point, erect danger-boards to prevent any person entering, and keep up a brisk ventilation so as to dilute and carry away any gas which might be liberated, and see that the reports under General Rules 4 and 7 were duly entered up. After the roof had settled, I should make a thorough examination with a locked safety-lamp as to gas having been given off or contained in the break at the coal face, replace all timber that was broken, shift any rubbish that was left, and if necessary either "line" or set fresh bars in the drawing road before allowing coal drawing to be resumed. Before commencing work again I should see that the colliers made the vicinity of the broken roof safe, and as soon as possible got some timber under the new roof.

Fred Hutchinson, 27, Longfield Road, St. Helens Road, Bolton.

W. T. Hughes, I. Isaac, D. Thomas, C. Addison, W. Heys (*12 marks each*).

Safety Valves.

Q. 10.—*What is the object of a safety valve on a steam boiler? What form of safety valve would you use?*

A.—A safety valve is an important fitting of the steam boiler, as the correct working of the same is responsible for the safety of the boiler. The function of the safety valve is to determine the pressure above which the steam shall not rise, that is to say, suppose the boiler is intended to work at a pressure of 100lb. on the square inch, the safety valve will allow the pressure to rise to that point, but not beyond (provided it is in safe working order), because the valve will open and allow the steam to blow off into the atmosphere. It is quite evident that such an appliance is an absolute necessity, not only as fixing the pressure at which we wish to work, but because, if such an appliance was not at our command, the boiler pressure might, and probably would, rise indefinitely, and disaster would be the result.

Safety valves, besides being accurately loaded and fitted so as to blow off at the required pressure, should have a discharging power sufficient to prevent any material increase of

pressure under all conditions of working. Under ordinary conditions of working the steam generated in a boiler flows freely into the engine cylinder or elsewhere, and with good stoking the quantity required will be regulated so as to prevent any loss through "blowing off." It should be distinctly understood that all steam discharged through the safety valve is so much heat or power wasted, and it should be the aim of all boiler attendants to economise in this respect as much as possible. Circumstances will occur, however, which render a great discharge of steam through the safety valves a necessity. An unexpected stoppage of engines when the fires have been made up for full work will rapidly cause an increase of pressure, and unless the safety valve outlet is equal to such an emergency the pressure may accumulate to a dangerous extent.

The pressure upon the outside of the valves may be produced by a simple lever and weight, by a dead weight, or by a spring. The first two methods are usually adopted for stationary boilers. Notwithstanding the fact that most stationary land boilers are equipped with some form of lever safety valve, I think that, taking all things into consideration, it cannot compare with the dead weight safety valve. The dead weight safety valve is the one I should prefer, but it must be stated that it is customary to employ two safety valves, usually the dead-weight valve and the lever safety valve.

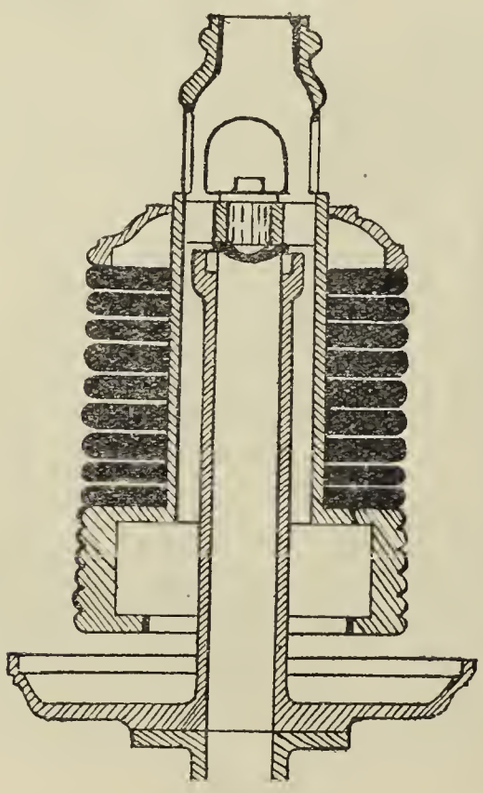
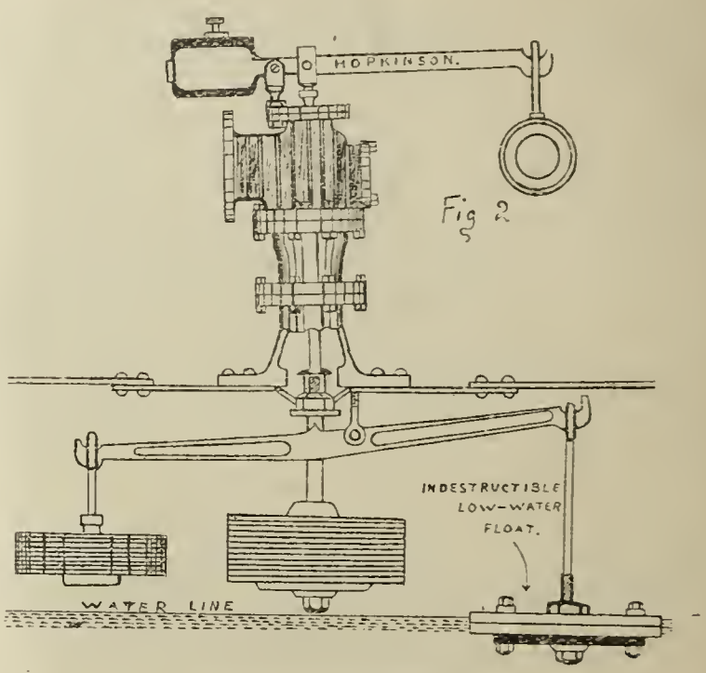


Figure 1, illustrating Question 10.

Dead-Weight Safety Valve.—This type of safety valve, if of proper construction, possesses many advantages over that of the lever type, and it hardly need be said that it is coming into regular use. The valve is a portion of a sphere, without spindle or wings, as in the case of the lever safety valve, and always fits right whatever its position; it cannot tilt, [and therefore cannot wedge. There is no lever, the weights surrounding the valve, the centre of gravity being below the seating. The total weight upon the valve has to equal the working pressure in lb. per square inch multiplied by the area of the valve in square inches. That is to say, a boiler working at 100lb. pressure with a four-inch safety valve would have to be weighted with $100 \times 12\frac{1}{2} = 1{,}250$lb. The dead-weight valve is undoubtedly an excellent one, and always works correctly. Dead-weight safety valves made by recognised makers will start blowing off immediately the working pressure is exceeded, and will close immediately the pressure falls a fraction below the working point. They cannot be tampered with with the same ease as the lever type of safety valve. The dead-weight safety valve only prevents excess of steam pressure, and theoretically this is all a safety valve should be required to perform. See *Figure 1.*

Combined High Pressure and Low Water Safety Valve.—Many engineers prefer to adopt a type of safety valve that is simply designed to prevent excess of steam pressure, to the exclusion of all other types, so as to avoid what they term undesirable complications. The above type of safety valve mentioned in the heading, constructed by a noted firm, does not possess any complication, or at least few parts that can get out of order. By some cause the water in the boiler may be allowed to fall too low, endangering the safety of the boiler by laying bare the crown of the flues to the action of the heat. As a safeguard in this case, what we call a low water safety valve is applied, which, when the water falls too low, opens, and the steam blows away whatever the pressure. The principle of this low water safety valve is shown in *Figure 2.*

In another form of high pressure low water safety valve the direct pressure of the steam overcomes the pressure of the central weights, when the water in the boiler is allowed to fall too low or rise too high, a float causes a valve to lift, and so allows the steam to blow an alarm whistle. If the attendant is not present it may draw his attention or some other person in the vicinity of the boiler house.



Illustrating Question 10.

Whatever the type of safety valve selected, it is an absolute necessity that it should be thoroughly reliable, although, of course, the greatest care is necessary to guard against accidents arising from the safety valves being tampered with or otherwise becoming defective.

Indebted for a part of this answer and sketches to PERCY'S *Mechanical Equipment of Collieries.*

WALTER HEYS, 1, Walter Street, Huncoat, Accrington.

[NOTE.—Undoubtedly the most reliable safety valve under all circumstances is the dead-weight safety valve. It is not so easily tampered with as the lever and weight, and the effects of any overloading are not increased by the leverage as they are in the latter case. If we look at a boiler with both classes of valve and notice the big difference in the size of the two weights, we can easily see that a small additional weight in the case of the lever must raise the blowing off pressure much more than it would in the case of the dead-weight. Personally we prefer a safety valve of each type on a boiler, the lever type being connected in addition with a float in order to blow off in case the water sinks below the level permissible.—C.C.M.]

F. Hutchinson, F. J. Aston, G. Addison (*12 marks each*). . .

Ventilation.

Q. 11.—*What precautions would you make at a colliery for keeping up the ventilation in case of a breakdown of the ventilating appliances? In the event of a serious stoppage of ventilation when the men were at work, what action would you take?*

A.—Under modern mining conditions, where the seams worked are fiery, and the workings extend over a considerable area, the above question is an important one, inasmuch as not only is the ordinary working of the mine interrupted, but the safety of the persons working in the mine is endangered, that is, of course, providing safety arrangements have not been previously considered. To deal with the first part of the question in a practical manner, the question may be viewed from several standpoints, *i.e.*, situation of shafts, number of downcasts and upcasts, extent of workings, nature of seam, as to whether fiery or otherwise, &c., and each of these may affect the arrangements subsequently adopted.

Temporary Arrangements for Keeping Up the Ventilation.—Various methods may be employed for this purpose, notably by means of furnaces, wind cowls, connecting upcast shaft to the boiler stack, waterfall in downcast, steam jets in upcast, and also duplicate fans. In modern collieries the usual precautions taken for keeping up the ventilation consist of the three latter methods. Preferably these arrangements must be installed in readiness for immediate use.

Duplicate Fans.—Where a fan is used for ventilation purposes the best course to pursue is to install a duplicate ventilation plant, and so prepare for any emergency. In every respect, except, of course, that of expense, it is advisable to have two fans each distinct from the other, and also to have independent driving power. If expense has to be considered, the better course would be to use the same fan, but have a duplicate driving plant, one engine always being kept in reserve. Where both a duplicate fan and driving plant are installed, they should be run alternately, say a week at a time, to ensure that one fan and engine is in perfect running order, so that they could be brought into operation in a case of emergency. Where the fan is the same, but possessing a duplicate driving plant, the engines may be coupled up to the fan alternately, for purposes as explained above. The installation of a duplicate ventilation plant kept in perfect running order will obviously solve the first part of the question, as should one fan become disabled the safety of the mine and the persons working in the mine is assured.

Waterfalls.—Where a duplicate ventilation plant has not been installed, in case of a breakdown the ventilating current could be temporarily produced by the rather primitive method known as the "waterfall method." This arrangement consists of a vertical pipe line, contracted a little near the top. Immediately below the contracted part there are a number of small perforations. When water is poured into the pipes, air is drawn in through the holes and carried down by the water. In this way a downward current is produced in the downcast. The objections to this method are that either a pump must be installed to pump the water to the surface, or as an alternative there must necessarily be a good supply of surface water, and also a satisfactory water standage; that is, provided there is not an adit or water level—an unusual thing in deep modern mines. I should not care to adopt this method to temporarily ventilate a rather extensive mine, but it could be advantageously used in conjunction with the "steam jet."

Steam Jets.—Of the various methods adopted to temporarily continue the ventilation, that of the steam jet is perhaps the one most favoured. The steam jet arrangement consists of a steam pipe connected to the boilers at the surface, and taken for a certain distance down the shaft. These steam pipes are connected to a circular ring of pipes passing round the shaft, the upper part of the ring being provided with perforations of very small bore. The steam from the boilers passes down the vertical line of steam pipes, passes round the horizontal vertical ring of pipes, and finally issues in small jets from the perforations at considerable pressure. This action rarefies and reduces the density of the air in the upcast, consequently a difference of pressure is created in the two shafts, thus creating a ventilative current. In addition to rarefying the air in the upcast the pressure of the small jets of steam issuing from the circular pipe imparts a certain degree of momentum to it, thus helping to create a ventilating current. The cover of the upcast must necessarily be removed to allow the air to escape. This arrangement is easily applied, and is exceedingly useful in cases of emergency, and when used in conjunction with the waterfall method would in all probability be sufficient to temporarily ventilate the mine in an adequate manner, providing the mine was not very fiery and extensive. At all events these are the methods which I should provide, and have fitted up, so as to be ready for operation in the case of a breakdown of the ventilating apparatus.

If these arrangements are found suitable for ventilating the mine in accordance with the provisions of General Rule 1, the necessary repairs to the fan may be carried forward as expeditiously as possible. If these arrangements proved inadequate the only course would be to withdraw the men from the mine, and stop all underground work in the main workings until the repairs had been completed.

In all cases of a sudden stoppage of ventilation caused by a breakdown of the ventilating appliances, the best and safest course would be to withdraw the men from the mine.

The proper course of action should be mapped out beforehand by the management in such a manner that no misunderstandings can possibly occur, as this may turn out to be a serious matter under the exceptional circumstances. The following method is the one adopted at the mine where I am employed, and is undoubtedly a safe and practical one.

Each person employed underground is given the same lamp each morning, each lamp having a distinguishing number, and he also possesses a "time check" with the same number. Upon arrival at the surface lamp cabin before commencing work, he passes the time check to the lamp-man and is given his lamp in return, the check being hung upon a board in the lamp room. No lamp is given out unless the time check is given up, except with the under-manager's permission. Upon arrival at the lamp station underground, each collier puts upon another board a "tub tally," with his own number upon it before he is allowed to proceed to his working place.

A special signal is arranged and posted up along with the winding and haulage signals, and when the whole of the men have to be withdrawn this signal is given, and must be returned to show that it is understood. The dataller or other competent person whose duty it is to see that all the persons have left the district at the end of each shift, must make certain that every drawer or haulier has left the jinney, and that word as to the withdrawal has been sent to every getter on the face, and incidentally all other persons working in the district. He should then, in company with the fireman, make his way along the usual travelling road to the tally board referred to above, and see that every check or tally has been taken off. If the tally board is empty he may conclude that each getter has left the district, but if any tally has been left upon the board he must proceed by the travelling road this collier must travel to get to the tally board, until he arrives at the collier's working place. In this way it is practically impossible for a collier to be left behind. Upon himself leaving the district, he must proceed along the usual travelling road to the shaft, taking care to see that the men in the district do not linger along the way.

As each person arrives at the surface he hands in his lamp and receives his check in return. When the person responsible for seeing that the men in his district are out of the mine arrives at the lamp station at the surface, he receives his own check, and at the same time examines the board in the lamp cabin. If any person's check has been left upon the board corresponding to a person's number working in his district, he must report the occurrence to the under-manager, who must organise a search for the person left in the mine. If the tally board is clear the person in charge of the men must sign his name to the board, thus signifying that all persons in his charge are clear of the mine.

Nothing should be left to chance, it being clear from the above that safety arrangements must be made and thoroughly understood before a case of emergency arises. If telephones are provided in each district seeing the men out of the mine becomes much facilitated, since in all cases of doubt reference can be quickly made to the lamp-man at the surface.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

[NOTE.—We think we are correct in saying that each competitor in answering this question suggested that there should be secondary or spare ventilating engines in case of a mishap. The question as put seems to imply that the whole of the available appliances are broken down, or at any rate disabled in such a manner that some totally different method of keeping the ventilating current in motion must be adopted. Undoubtedly if there was a serious stoppage when the men were at work they should all be immediately brought out without hesitation. It is surprising how quite a brisk current will pass for days after a fan has been quite stopped. Of course, a lot depends upon whether the upcast shaft is so due to natural ventilation independent of the fan or not. Of course, if the downcast shaft was naturally the upcast the current would soon reverse after the fan was stopped, and such a result might be disastrous if the men were not quickly brought out. We have seen water thrown down the downcast in order to keep the current going temporarily. The easiest way to do this is to wind the water from the sump if there is any there, as in our own experience there generally has been, and then allow it to fall from the bank down the shaft again. Another method is to put a perforated steam pipe round the inside of the upcast shaft, a little way down, and turn steam into the pipe. The pipe must not be put too far down the shaft, or it will defeat its object, as condensation will take place, and the water fall down the shaft. Another good plan to temporarily restore the ventilation is to connect the top of the upcast with a chimney stack, when a brisk current of air through the mine will often be maintained.—C.C.M.]

G. Addison, F. J. Aston, F. Hutchinson, I. Isaac, W. T. Hughes (*12 marks each*).

Winding Engines.

Q. 12.—*Is it necessary in colliery winding engines on the second motion to have a brake applied both to the crank shaft and also to the drum itself? Give reasons for your answer.*

A.—By an engine on the second motion we necessarily mean a "geared" engine, or one in which it is the practice to put a pinion upon the crank shaft and a spur wheel upon the drum shaft, a flywheel being necessary to assist the engine over the centre. All these moving parts have to be put in motion before the actual wind commences, hence the term "second motion" applied to it.

On referring to the question, it is not, in my opinion, absolutely necessary to have a brake applied both to the crank shaft and also to the drum itself. However, in rare instances two such brakes are employed, as a safety precaution, where "geared" engines are in use. The common practice of using a brake on the flywheel is defective, unless it is used in conjunction with a brake on the drum itself. It is quite evident that if anything were to happen to the engine, say an accident of such a nature as to allow the cages to get away, the crank shaft would be subjected to such an enormous torsional strain, due to the continued application of the brake on the rim of the flywheel, that, should no brake be attached, fracture may eventually take place, and the inevitable result is disaster. Many accidents are liable to occur to the engine, and if a brake on the crank shaft is used solely for the purpose of control it will frequently be found that such a brake is practically useless. Where a drum brake is used as a preventive, in conjunction with the crank shaft brake, it is most imperative to have the levers controlling both brakes in close proximity to the engineman, because if he has to run round to the drum to apply its brake in the event of the crank shaft brake failing, then we are courting disaster.

Again, when about to install a winding engine, whether "geared" or driven "direct," we cannot overlook the stipulations and requirements of General Rule 30 of the C.M.R.A., which states that "every machine, worked by steam, water, or mechanical power, and used for the purpose of lowering or raising persons, must have an adeqaute brake attached," and also of no less importance is the following addition to the above rule:—"If the drum is not on the crank shaft there shall be an adequate brake on the drum shaft." In the latter portion of this rule it is quite clear that where "geared" engines are used for winding purposes there must be attached an adequate brake to the drum shaft. Hence, wherever else we may wish to put a brake we are bound to have one on the drum shaft, that is to say, we must have one directly acting on the circumference of the drum, because otherwise there would be no means of arresting the drum should anything happen to the cogs or gearing.

From the fact that crank shaft brakes are defective, and that they are not an absolute necessity to the winding engine, also seeing that a drum brake is a compulsory and necessary equipment to the engine, we are very apt to ask "What is an adequate brake?" For my part I contend that the brake power should in every case be sufficient to hold the loaded cage at any point in the shaft without the application of steam pressure against the engine. This is also my reason for the contention that a brake is not absolutely necessary on the crank shaft, because if we employ an adequate brake on the drum shaft the use of a brake on the crank shaft is useless, except as a standbye, the adoption of which is not highly favourable to the mining community. To ensure the greatest efficiency of the brakes they must act directly upon the drum, for by so doing, in the event of an accident to the winding engine the brake acting upon the circumference of the drum will be quite capable of controlling the load in the shaft.

The usual kind of brake attached to second motion winding engines is one which is double-acting, that is, one built in two parts, entirely surrounding the brake rim attached to the drum. The brake straps are made of wrought-iron lined with hard wood, made adjustable, and actuated by a wrought-iron foot lever. Both brakes are worked from this lever, situated at the engineer's feet, with a toothed wheel to maintain the pressure, after being first applied by catching into a toothed plate through which the lever works.

Various brakes have been devised for use on colliery winding engines, all of which, for the purpose of classification, may be brought under three heads, according to the brake power. First, those put into operation by manual labour, and in which the brake power would seem to be low; second, those actuated through the medium of weights, and in which the brake power may be termed medium; third, those brought into operation by the application of steam, and in which the brake power may be considered as of the greatest efficiency.

In the third system we have what may be termed "an adequate brake," for by the application of steam the power is obtained by the action of steam upon a piston in a small cylinder, levers being connected to the piston rod, and the necessary brake arrangements.

Fred J. Aston, 24, Cooper's Lane, Haydock.

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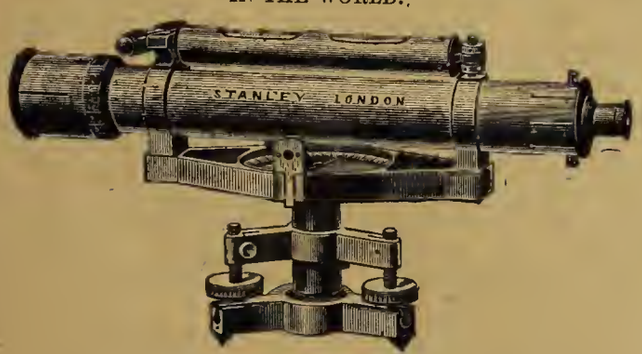

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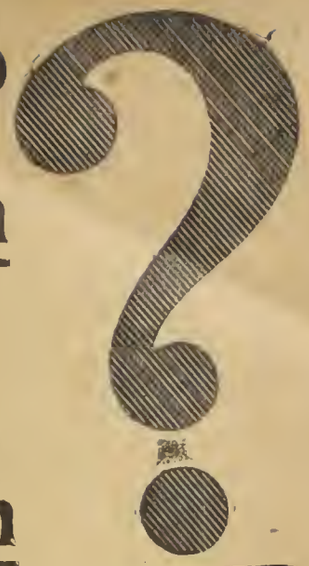

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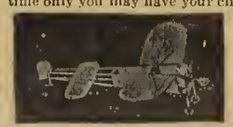

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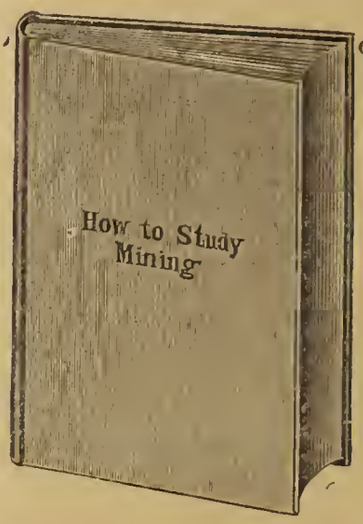

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The Science and Art of Mining.

VOL. XXII.—No. 24] SATURDAY, JULY 6, 1912. [PRICE 3d.

NEWS AND NOTES.

Preliminary Notice.

In the forthcoming issue of *The Science and Art of Mining* we hope to announce an entirely new departure in the Prize Competition for Volume 23. Arrangements are being made to afford through the medium of this Competition a progressive course of instruction for firemen, and for students who aim at securing their parchment as Second Class and First Class Colliery Managers. This feature will thus become a useful and important one for all engaged in the serious study of mining, and we appeal to all present readers to direct the attention of their fellow workers and students to *The Science and Art of Mining* with special reference to the numerous features of interest. Or send along to the Office of this Journal the addresses of friends likely to be interested, and we will mail to them direct a complimentary copy so that they may see for themselves the importance of the Journal to them. It is desirable to secure the fullest benefit from the Prize Competition to commence with the questions to be published in the next issue, viz., No. 25, Vol. 22.

Public Elementary Schools in Mining Districts.

A circular on the subject of elementary instruction in mining has been sent to Local Education Authorities by the Board of Education, as follows :—

1.—In the Report of the Royal Commission on Mines attention was drawn to the desirability of introducing into the curriculum of schools in mining districts some elementary instruction in regard to mining. The Home Office and the Board of Education, after consultation, have agreed to issue jointly the following statement of their conclusions for the information of Local Education Authorities in mining districts.

2.—It is not suggested that any advanced or specialised instruction in mining should be attempted in Elementary Schools, but only such simple instruction with regard to the nature, occurrence, and use of the minerals worked in the district, the general methods of getting the minerals, the dangers which have to be guarded against, and similar topics connected with mining as would interest school children and create a desire to know more. Such instruction would most effectively be given not in the form of separate and detached lessons, but in connection with the ordinary instruction of the school. Where this can be done, the Board of Education would have no objection to such instruction being included in the curriculum of the school.

3.—It is probable, however, that there may be considerable difficulty in finding teachers competent to give instruction of this kind as part of the ordinary school course, unless special measures are taken to give the teachers in mining districts facilities for qualifying themselves for this purpose. It is doubtful whether attendance at ordinary mining classes, *i.e.*, at evening and other classes, provided to meet the needs of working miners, would be really satisfactory for this purpose. It would be preferable, if possible, that special classes should be formed for Elementary School Teachers, and that the teachers of these classes should not only have a thorough knowledge of mining, but should also understand thoroughly what can be taught to Public Elementary School Children.

Bonus to Miners.

The Denaby and Cadeby Collieries, Ltd., have hit upon a method of dealing with their obligations under the Minimum Wages Act, and propose to pay the minimum on a new principle. They have agreed to bestow upon their 4,000 underground workers who come under the operation of the Act a 10 per cent. advance, which brings the percentage up to 60. This extra percentage will not be given to men direct, but will go to create a fund for the payment of minimum wage claims. Every three months, after all claims under the Act have been satisfied, the fund will be disbursed in the form of bonus among the workers, the amount of the bonus being entirely regulated by the number of calls which have been made on the fund during the quarter. Thus (a contemporary says) it is to the interest of every workman to earn the minimum if he can, and so benefit as much as possible from the bonus. Those who make claims most frequently on the funds will find their bonus correspondingly reduced. The system is unquestionably directed towards maintaining the output by compelling a fair day's work for a fair day's wage, and this is done by instituting the spirit of co-operation among the men. Shirking and incompetence are automatically barred by both employers and workmen, for it is to the common interest that the minimum wage should be earned. Doubtless if the first experimental three months proves successful the principle will be generally adopted throughout coal mining. The arrangement at Denaby and Cadeby, which is understood to have the wholehearted approval of the men, is terminable at three months' notice at the beginning of the quarter.

The Lomax Laboratories.

Members of the Manchester Geological and Mining Society recently visited the Lomax Palæobotanical Laboratories, Bolton, to see the collection of micro-sections, transparencies, drawings, micro-photographs, specimens, &c., showing the natural history of coal and the inflammable and resinous bodies in coal and coal dust. The collection contains over two hundred preparations and specimens of Lancashire, Yorkshire, Staffordshire, and Welsh coals ; also a large number of fossil plants and sections of fossil plants. Mr. W. E. Garforth, of the Pope and Pearson Collieries, Yorkshire, has purchased the collection for the reason that it illustrates the origin and constituent elements of coal, and throws light on the coal dust experiments with which his name is associated. The Lomax Laboratories are the outcome of many years of laborious research. Mr. Lomax used to confine himself almost wholly to palæobotanical and general petrological work, but the accident at the Pretoria pit of the Hulton Collieries led him to give special attention to the task of determining, by the aid of the microscope, in an exacter fashion than had been possible before, the nature and quality of coal and coal dust. He had some specimens of the Hulton coal in his possession before the explosion took place. After the explosion he got other specimens of both coal and dust from the mine, and made a thorough microscopic examination of them. That examination confirmed the view he had previously formed—namely, that the coal was highly charged with resinous matter, the product, in his opinion, of resinous exudations of various plants which flourished in the carboniferous ages. He claims that the microscope is surer than chemical analysis in determining the inflammability of coal. As mines get deeper and the necessity of swifter and larger volumes of air increases so will the usefulness, it would seem, of this method become more evident, because with greater volumes of air there will be more dust.

NOTES FROM WALES.

By BRYCHAN.

Haulage—(continued).

The Construction and Use of Ropes.—The student of mining and engineering should avail himself of any opportunity which presents itself of making a visit to a rope manufactory. The actual construction or putting together of the various wires and the respective strands must be seen to be understood; there are also some general principles which must be observed in the designing, if the best results are to be obtained. It is well known that a rope which stands a certain stress at a testing machine before giving way, will prove to be equal to a greater stress if the wires are taken *singly*, and the aggregate strength calculated by totalling the stresses undergone by each of the wires. That is to say, the rope as a whole is not nearly so strong as the joint strength of the individual wires. This is accounted for by the facts that: (1) The twisting of the wires and strands, so necessary to impart unity to the structure, is done at a sacrifice of strength; (2) it is seldom possible to subject each wire to the same pull while the rope is undergoing a test. The result is that some of the wires which are subjected to the maximum tension break before other wires have taken their fair share of the load. This is, of course, a problem for ropemakers, and great pains are taken to ensure each wire being laid in such a way that it will bear its fair proportion of the load; the result is to reduce the loss between the *aggregate* strength of the wires and the *ultimate* strength of a rope to a minimum, and secure a rope of nearly perfect formation.

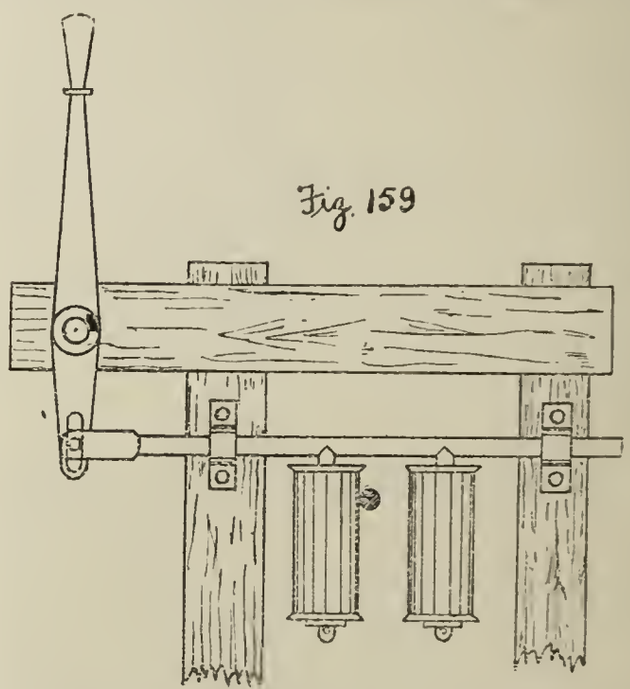
It is usual to test each wire for tension and torsion before it is put into a rope. This is done while the wire is still in the bundle, and before it is wound on the bobbins. A record of the behaviour of every wire under torsional and tensile stress is entered by the tester in a book kept specially for the purpose, so that in the event of information being sought, perhaps years hence, about a particular rope supplied, all details are at once available.

As an example of the excellent quality of steel wire frequently adopted for ropes, an instance may be given of a wire 0·113 inch diameter in a test for tensile stress breaking with a pull of 2,509lb. This is equal to a breaking stress of 112 tons per square inch of sectional area. Another portion of the same wire was tested for torsion. The distance between the grips was about 15 inches, and 31 complete revolutions were given before the wire broke. Steel wire can be drawn to a stress of even 130 tons per square inch.

Treatment of Wire Ropes while in Use.—Ropes should be uncoiled from a turn-table, and very carefully, or kinking will result, which spoils the rope. This is due to the spring or life in a new rope, which, if there is considerable slack rope between the turn-table and the drum, causes it to fly into a coil, which, as a rule, will not right itself unless personally attended to. Too much slack rope should therefore be avoided; on the other hand, the motor should never be allowed to pull the turn-table round. There should always be sufficient assistance to ensure the rope being paid out at the same rate as it is pulled in on to the drum. When a rope kinks the strength at that point is materially reduced, owing to the short twist that has taken place. Moreover the rope cannot afterwards be expected to coil symmetrically on its drum, and good coiling is essential for smooth, efficient and safe working.

The influence of the size and design of pulleys and drums on the ropes which work upon them should be carefully noted. The life of a rope is materially reduced if made to work round small drums and pulleys. Buckling is set up, the rope is flattened, or, strictly speaking, becomes elliptical, and when not in tension takes the form of a spiral. When considering the size of pulleys for underground haulage, convenience of handling is the important factor, and therefore the ratio usually observed between the size of a *winding* rope and its pulleys or drums is much reduced. For underground haulage a satisfactory workable minimum diameter for a sheave or pulley is 60 times the diameter of the rope. Thus a ¾ inch diameter rope would require a pulley 3 feet 9 inches diameter on tread. If the pulley is larger the rope is so much the better for it, but if made smaller, then, unless the rope is of special construction, it is done at the risk of injuring the rope. A high *speed* of rope means a considerable amount of wear, while an increased *load* is not nearly so harmful. That is to say, it is better to increase the load than the speed. These points are worthy of note when the comparative merits of main and tail and endless rope are under discussion. Jerking is ruinous to ropes, and a careless engineman may easily, by picking up his load rashly, snap even a new rope. Consequently the inertia of the load should be very gradually destroyed, and a careful engineman will always bring his load from rest up to full speed with perfect smoothness.

Ropes before use should be stored in a dry place, upon timbers, and, if left a long time, oiled over occasionally. Where they are not galvanised ample protection should be afforded by a suitable oil, free from any ingredient which might set up corrosion. Winding ropes are usually well served in this respect, while haulage ropes are just as much neglected. The following test shows the importance of greasing ropes: Two lengths of rope, same size, same make, one oiled, the other unoiled. The latter made 16,000 bends, and the former 38,700 bends over the same pulley before breaking. Again, similar pieces were tested over a 24-inch pulley. The unoiled stood 74,000 bends, and the oiled 386,000 bends before breaking.



It has already been pointed out that symmetrical coiling on its drum is an essential factor for the maintenance in good order of a wire rope. Haulage drums are usually narrow, and therefore the amount of side travel for the rope is not excessive. Nevertheless, there are many examples of haulage gears where the ropes do not coil symmetrically, *i.e.*, they cannot do so without some assistance. One crude device is to use a wooden or iron bar (as a lever of the second order) in the immediate vicinity of the drum, to push the rope into position. This is undesirable and dangerous, and there are better mechanical devices in use for coiling. (*Figure 159*). The arrangement of levers connecting with the roller shafting will of course depend upon the local conditions.

As a rule the difficulty of coiling symmetrically will (other things being equal) increase as the stress on the rope. This is because the rope, having a less tendency to sag or swing, will tend to coil in the same plane, until finally the whole mass of rope topples over, perhaps fracturing the drum cheek, and certainly ensuring a lively time when that particular rope is being run out when the set is travelling in the opposite direction. A travelling pulley in front of the drum often assists materially in coiling the rope; but the most important point of all is to provide for the rope sufficient sag or swing between the drums and the nearest fixed point, which may be a carrier pulley or something of the sort. The rope is then enabled to accommodate itself to the trifling side travel necessary to ensure

symmetrical coiling up against both cheeks of the drum. This point should be kept in mind when fixing the site for an engine-room in a recess more or less at right angles to the engine plane. The engine house should be built a liberal distance inwards from the plane so that between the sharp bends of the ropes in passing out on to the engine plane, and their drums, there will be such a swing as to ensure no difficulty of working in the future.

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries, The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper, (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications.

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Would you kindly ask TYKE to answer these two questions for me, through your most valuable paper, *The Science and Art of Mining*:—

1.—Has an examiner, appointed by the workmen, to make an examination of the mine in which they are employed, a legal right to cross a firemark or fence without authority from an official?

2.—In the event of an accumulation of fire-damp about the workings of the mine, when workmen are on the return side, what must they do; have the examiners a right to go and tell the men about the danger, or must the workmen be allowed to work in ignorance of the danger to which they are exposed?

Thanking you in anticipation.

Yours, &c,.

MON. READER.

To the Editor of The Science and Art of Mining.

SIR,—Will any reader of this Journal furnish answers to the following questions:—

(1). What are the common rock-forming minerals which occur in meteorites? What terrestrial rocks resemble the meteorites most closely in constitution?

(2). What are the red and blue tints in the Pennant Sandstone (Carboniferous Formation) attributed to?

Yours, &c.,

JOHN.

To the Editor of The Science and Art of Mining.

SIR,—Will you please insert the following in *The Science and Art of Mining*:—

A heading 12 feet wide and 8 feet high, dipping 15 inches per yard, is used for a lodgeroom (sump). If the water is raised 20 yards along the slope, how many gallons of water are there?

Yours, &c.,

MINER.

To the Editor of The Science and Art of Mining.

SIR,—I should like here to thank TYKE for his very able answer in No. 20, Volume 22, of your paper, to my question *re* "The effect on the water-gauge by a fall of roof in the main return air-way."

I am much enlightened on the matter by the answer.

Now looking up the Coal Mines Act, 1911, I find another very practical question with regard to ventilation. Rule 31 (3) states "that after the 1st day of January, 1913, there shall in every mine in which a mechanical contrivance is used for ventilation, be provided and maintained in a condition to be put into immediate operation adequate means for *reversing the air current*."

This contrivance must be capable of producing a sufficient ventilation, and according to rule will have to be used at least *once a week*.

Now I shall be glad if you will answer the question in your paper as to how this reversing the air current is to be done, supposing that at present the ventilation is produced by the exhaust fan from the upcast shaft, the type of fan being the closed Guibal.

Thanking you in anticipation.

Yours, &c.,

J. W. T.

Arithmetic.

To the Editor of The Science and Art of Mining.

SIR,—I have attemped to arrive at a solution to the following question by GLAMORGAN STUDENT in No. 22, Vol. 22:—

Q.—A mass of lead ore weighs 7 tons. One portion yields 78 per cent. of lead, and 8 ounces of silver per ton; the remainder yields lead 75 per cent. and $7\frac{1}{2}$ ounces of silver per ton. The total yield of silver is 5 ounces. What average percentage of lead does the whole mass contain?

A.—Let the first portion be equal to x tons.

$\therefore$ The second portion will be equal to $7 - x$ tons.

The first portion has 8 ounces of silver per ton; the second $7\frac{1}{2}$ ounces of silver per ton, and the total yield of silver is 55 ounces.

$\therefore 8x + \frac{15}{2}(7 - x) = 55 = 16x + 105 - 15x = 110.$

$\therefore x = 110 - 105 = 5.$

$\therefore$ The first portion equal 5 tons.

Now the first portion contains 78 per cent. of lead, *i.e.*, 78 per cent. of 5 tons $= \frac{\cdot 78}{100} \times \frac{5}{1} = 3{\cdot}9$ tons of lead.

The second $7 - 5 = 2$ tons.

The second 75 per cent. of lead, *i.e.*, 75 per cent. of two tons $= \frac{\cdot 75}{100} \times \frac{5}{1} = 1{\cdot}5$ tons of lead.

$\therefore$ Total yield of lead in whole mass $= 3{\cdot}9 + 1{\cdot}5 = 5{\cdot}4$ tons.

$\therefore$ Average percentage of lead is equal to

$\frac{5{\cdot}4}{7} \times \frac{100}{1} = 77{\cdot}142857$ per cent.—Answer.

Yours, &c.,

J. STUART EVANS.

To the Editor of The Science and Art of Mining.

SIR,—In answer to GLAMORGAN STUDENT I beg to send in the following solution, hoping that if it is not correct some other reader will rectify the error:—

It is evident that the 7 tons must be divided into two parts, so that 8 times the first part + $7\frac{1}{2}$ times the second part must equal 55.

Let x = one part. Then $7 - x$ = second part.

$8x + 52\frac{1}{2} - 7\frac{1}{2}x = 55 \quad 8x - 7\frac{1}{2}x = 55 - 52\frac{1}{2} \quad \frac{1}{2}x = 2\frac{1}{2}.$

$\therefore x = 5.$

$\therefore$ One portion of the mass weighs 5 tons.

The other portion of the mass weighs 2 tons.

Amount of lead:—

First portion = 78 per cent. of 5 tons $= 3\frac{9}{10}$ tons.

Second portion = 75 per cent. of 2 tons $= 1\frac{1}{2}$ tons.

Total lead in mass, $3\frac{9}{10} + 1\frac{1}{2} = 5\frac{2}{5}$ tons.

Average percentage $= \frac{100 \times 5\frac{2}{5}}{7} = 77\frac{1}{9}$ per cent.—Answer.

Yours, &c., A. L.

South Wales Mining Examinations.

To the Editor of The Science and Art of Mining

SIR,—For the sake of your numerous readers, may I point out to your contributor of South Wales Examination Questions of the Second Class, May, 1912, that Questions 2 and 3 of Coal Working are appreciably different to what he submits. Actually the questions concerned are as follows:—

2.—Give your opinion as to the advantages of the use of coal-cutting machines and the conditions in which hand-cutting or machines are respectively most advantageous.

3.—Give sketches of air crossings, and state your views regarding them.

Yours, &c.,

DANIEL DAVIES.

["TYKE" proposes to deal with the questions submitted by "J. W. T.," "Mon. Reader," "Miner," and "John" in in their turn, as time and space permit.]

COLLIERY ENGINEERING.

By CLANSMAN.

Graphical Methods—(continued).

Figure 19 shows the graphs of $2x^2$, x^2, $\frac{1}{2}x^2$, $-x^2$, $x^2 - x - 16$. The following table gives calculated values of the function y for the values of x stated in the first column :—

When values of x are	6	5	4	3	2	1	0	−1	−2	−3	−4	−5	−6
Values of $y = 2x^2$ are	72	50	32	18	8	2	0	2	8	18	32	50	72
Values of $y = x^2$ are	36	25	16	9	4	1	0	1	4	9	16	25	36
Values of $y = \frac{1}{2}x^2$ are	18	12·5	8	4·5	2	·5	0	·5	2	4·5	8	12·5	18
Values of $y = -x^2$ are	−36	−25	−16	−9	−4	−1	0	−1	−4	−9	−16	−25	−36
Values of $y = x^2 - x - 16$ are	14	4	−4	−10	−14	−16	−16	−14	−10	−4	+4	+14	+26

Figure 20 shows the graph of $\sqrt{36 - x^2}$, $\sqrt{x^2 - 36}$, and of $\frac{1}{x}$:—

Taking the value of x as	6	5	4	3	2	1	0	−1	−2	−3	−4	−5	−6
Values of $y = \sqrt{36 - x^2}$ are	0	3·32	4·47	5·19	5·65	5·91	6	5·91	5·65	5·19	4·47	3·32	0

Taking value of x as	14	13	12	11	10	9	8	7	6	−6	−7	−8	−9	−10	−11	−12	−13	−14
Values of $y = \sqrt{x^2 - 36}$	12·64	11·5	10·39	9·21	8	6·7	5·3	3·6	0	0	3·6	5·3	6·7	8	9·21	10·39	11·5	12·64

Observe that a function which contains a square root of the independent variable may have either of the signs + and —. If the same scale is taken for both axes the portion of the graph between + 6 and — 6 is a circle whose radius is 6 units.

There are no real values outside $x = \pm 6$ in $y = \sqrt{36 - x^2}$.

There are no real values inside $x = \pm 6$ in $y = \sqrt{x^2 - 36}$.

For graph of $\frac{1}{x}$:—

Taking values of x as	∞	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	−1	−2	−3	−4	−5	−6
Values of $y = \frac{1}{x}$ are	0	$\frac{1}{16}$	$\frac{1}{15}$	$\frac{1}{14}$	$\frac{1}{13}$	$\frac{1}{12}$	$\frac{1}{11}$	$\frac{1}{10}$	$\frac{1}{9}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	1	−∞	−1	$-\frac{1}{2}$	$-\frac{1}{3}$	$-\frac{1}{4}$	$-\frac{1}{5}$	$-\frac{1}{6}$

This curve is not continuous, and it, therefore, appears in our graph in two portions ; neither is $y = \sqrt{x^2 - 36}$ continuous.

A curve whose equation is $y = ax^2$ is called a *Parabola*.

A curve whose equation is $xy = c$ or $y = \frac{c}{x}$ is a rectangular hyperbola.

Diagram of Work.—If we plot along the y-axis to scale any forces which are doing work, and the distances through which they act along the x-axis, we obtain a curve. If the force is constant the graph will be a straight line ; if it varies the graph may be a curved line.

The area enclosed by this curve and the axes will represent the total work done.

Thus, for example, if a force of 20lb. acts through a distance of 30 feet (*Figure 21*) represents the work done. The reader will observe that each square in the diagram represents a ft.lb., and that the total number of squares enclosed in the diagram is 600. Hence we say 20 × 30 = 600 ft.-lb.

Figure 22 is the diagram of work done by a force which is constantly varying, such as is obtained when a spring is stretched or compressed, or when a chain coiled on the ground is seized by one end and lifted vertically. In the case sketched a spring was slowly elongated 2 feet. The weight required was 100lb.

In practice the engineer finds the conditions under which machines perform work to vary greatly. He may find the force applied fairly constant and the distances regular ; the force varying and the distances regular ; the force constant and distances irregular ; or both forces and distances irregular. In short, to reckon the work performed by any machine he must first find the law of the machine relating forces applied with distances through which these forces act. The work diagram may therefore be a rectangle, a triangle, a combination of these, or indeed any other kind of plane figure. In every case, however, he must clearly understand what a square inch of the diagram means so that values can be fully calculated. Every diagram of work, whatever its shape, has two scales, *i.e.*, a *Force Scale* and a *Length Scale*.

One inch measured on the force scale represents a certain pre-arranged number of pounds, and one inch measured on the length scale represents a certain pre-arranged number of feet.

Suppose that one inch on the Force Scale = a pounds, and that one inch on the Length Scale = b feet.

Now, if we multiply the right-hand sides of these two equations we have b feet × a pounds, or ab foot-lb.

Multiply also the units on the left-hand of the equations, and we have a length of one inch × another length of one inch at right angles to the former, or an area equal to one square inch.

Hence, 1 square inch = ab ft.-lb., or, in other words, every square inch of a diagram of work represents the number of foot-pounds obtained by multiplying the number of pounds represented by 1 inch on the force scale by the number of feet represented by 1 inch on the length scale.

Area of Irregular Plane Figure.—The following methods may be adopted for finding the area of an irregularly shaped work diagram :—

First Method.—Take the sheet of paper on which the work diagram has been drawn. Cut out a square inch and weigh it ; then cut out the work diagram and weigh it. Then area of figure

$$= \frac{\text{Weight of diagram}}{\text{Weight of 1 square inch}}$$

Second Method.—Divide the irregular area into ten strips of equal width. Halve the width of each strip, and draw a dotted ordinate at each division. Take the length of each ordinate and add them all together. This sum multiplied by the width of one strip gives the area approximately. Perhaps the best way to get the sum of the ordinates is to take a long strip of paper and mark on it with a pencil the length of the first ordinate, to this add the second, then the third, fourth, and so on until the length of all the ten ordinates is marked on the strip ; then measure with an inch scale. The sum of the ordinates divided by ten would give the mean height, and in a work diagram this would represent the mean pressure acting over a distance represented by the length of the diagram.

Computing Scale.—Instead of a strip of paper, which is rather

awkward and difficult to manipulate accurately, the Computing Scale has been devised for this purpose. It is an ordinary ten-inch boxwood scale, carrying a small slider fitted with a crosshair. Each unit of length of one inch on the computing scale will represent an area depending upon the width of the strip into which the figure is divided. If the strips are one inch broad the units will represent square inches; if the strips are one-quarter inch broad, each unit will represent one-quarter square inch. To use any computing scale the actual value of the area represented by one inch of the scale is first determined without reference to the plan scale, and is equal in square inches to the width of strip in inches. To determine what one inch on the computing scale represents on the plan we must now multiply by the plan scale.

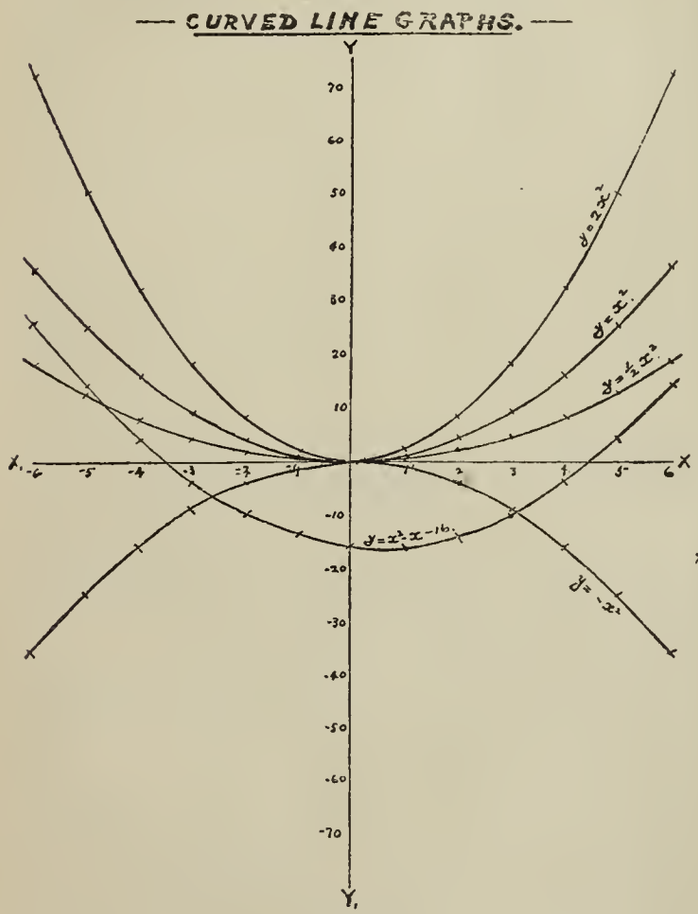


Figure 19.

Example.—If, on an indicator diagram, the force scale is 1 inch = 120 lb., and the length scale is 1 inch = 1½ foot, and if the diagram is divided into ten strips, each 0·3-inch wide, what is the area on the diagram if the computing scale gives the sum of the mid-ordinates as 6·4 inches; also how many ft.-lb. of work does this area represent?

One inch on the computing scale represents ·3 square inch.
∴ 6·4 inches on the computing scale represents 6·4 × ·3 = 1·92 square inches, *i.e.*, area of the diagram is 1·92 square inches.

From the scale of the diagram we know that 1 square inch = force scale × length scale = 120 × 1 ft.-lb.

Hence the diagram represents by its area an amount of work equal to 1·92 × 120 = 220·4 ft.-lb. done on each square inch of the engine's piston in one stroke.

Surface Areas.—To measure surface areas each unit of length equal to one inch represents an acre, and as the scale is divided into tenths we may take very accurate readings. The area must be divided into a number of strips of width to suit the computing scale. Thus, suppose that the height of one of these strips is OP and that the width is x. Then

Area of strip = ($OP \times x$) ÷ the number of inches on the scale representing 1 acre.

$$\therefore \frac{x \times OP}{\text{Plan scale}} = \frac{OP}{\text{Computing scale}}.$$

Here x gives the width of strip for any scale.

When, as mentioned above, the scale reads 1 inch = 1 acre, 1 acre = width of strip × 1, and therefore width of strip taken must be 1 inch.

Example.—If a plan is drawn to a scale of 1 inch = 4 chains, what width of strip must be taken to find the area with a computing scale which reads 1 inch = 1 acre.

Here $x = \frac{\text{Plan scale}}{\text{Computing scale}}$, and 1 square inch = 4 × 4 = 16 square chains = 1·6 acres.

$\therefore x = \frac{1{\cdot}6}{1}$ = 1·6-inch = width of strip required.

Third Method.—This is known as *Simpson's Rule.* First, draw a base line through the figure, and divide it into any number of equal parts. This ensures that the number of ordinates is odd. Erect an ordinate through each division. Then if

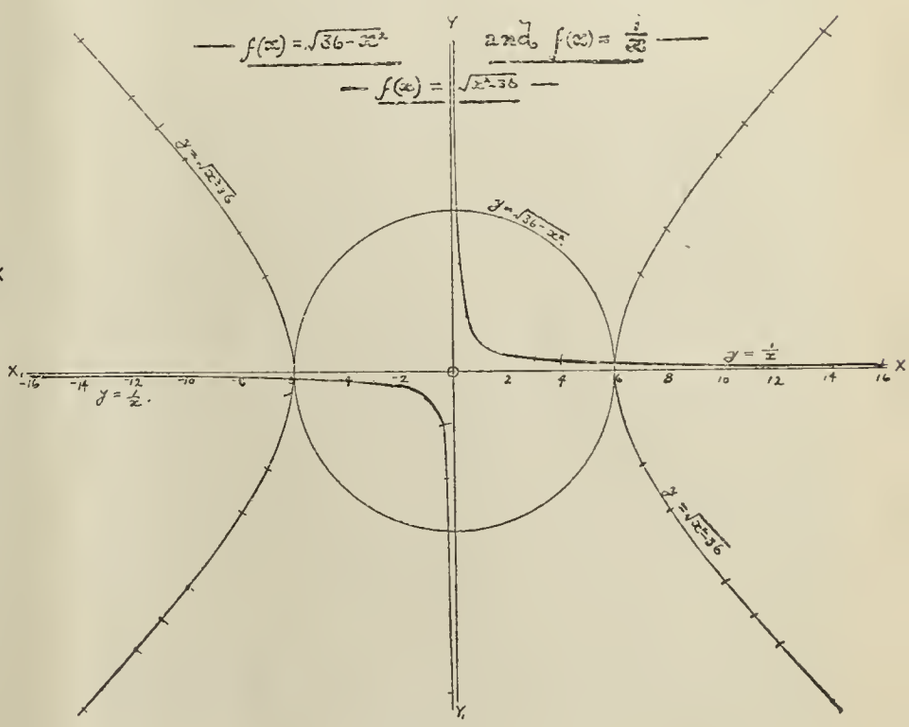


Figure 20.

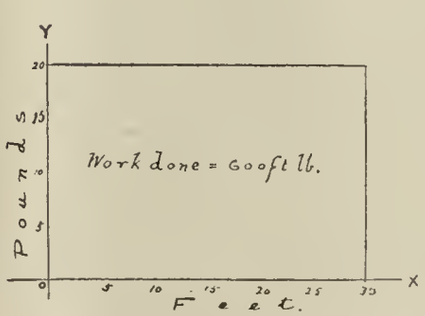


Figure 21.

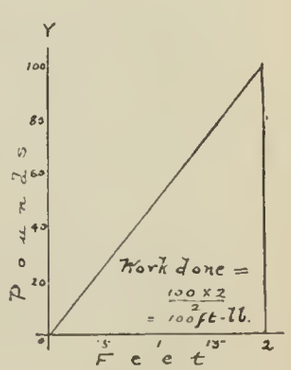


Figure 22.

S = the common distance between the ordinates;
A = the sum of the first and last ordinate;
B = the sum of all the even ordinates; and
C = the sum of all the odd ordinates.

$$\text{Area of figure} = \frac{S}{3}(A + 4B + 2C).$$

Example.—A force P acts along a line AB. The values of the force at A and at points 3, 6, 9 and 12 feet from A are respectively 55, 40, 35, 32 and 27lb. Calculate the amount of work done.

Here extreme ordinates = 55 + 27 = 82.
Remaining odd ordinates = 35.
Even ordinates = 40 + 32 = 72.
The common distance between the ordinates = 3 feet, and

$$\text{Work done} = \frac{S}{3}(A + 4B + 2C)$$
$$= \tfrac{3}{3}(82 + 72 \times 4 + 35 \times 2)$$
$$= 82 + 288 + 70 = 440 \text{ ft.-lb.}$$

EXPLOSIVES IN COAL MINES ORDER.

In pursuance of the power conferred on him by Section 61 of the Coal Mines Act, 1911, the Home Secretary has made the following Order regulating the supply, use and storage of explosives.

PART I.

1.—(*a*) No explosive substance shall be stored underground in any mine. The owner, agent or manager of the mine shall provide a suitable place or places of storage above ground for all explosives intended to be used in the mine, and shall make suitable provision conveniently near the entrance of the mine for the storage of surplus explosive brought out of the mine at the end of each shift. If any explosive remain in the possession of a workman at the end of his shift, either he shall bring it with him out of the mine and return it at once to the place of storage provided for the purpose, or, if the explosive is required for a shift immediately following, he shall deliver it personally to the workman succeeding him in his working place.

(*b*) No explosive shall be taken or used underground except in cartridges, and such cartridges shall be taken into the mine and kept until about to be used for the charging of a shot hole in a secure case or canister containing not more than five pounds, and a person shall not have in use at one time in any one place more than one of such cases or canisters. After the 31st day of March, 1913, no explosive shall be taken or used underground except in cartridges of the diameter of $\frac{7}{8}$in., $1\frac{1}{4}$-in., $1\frac{7}{16}$th in., $1\frac{3}{4}$ in., or 2 in., or in the ironstone mines in the Cleveland district, in cartridges of the diameter of $1\frac{3}{16}$th in.

(*c*) No drill shall be used for the boring of a shot hole unless it allows at least a clearance of $\frac{1}{8}$in., over the diameter of the cartridge which is intended to be used in the shot hole, and no person shall attempt to charge a shot hole unless such clearance exists.

(*d*) If explosives containing nitro-glycerine are used, proper warming pans shall be provided by the owner, agent, or manager, and used when necessary.

(*e*) Detonators shall not be used in or taken for the purpose of use into any mine unless the following conditions are observed:

(*i*) Detonators shall be under the control of the manager of the mine, or some person or persons specially appointed in writing by the manager for the purpose, and shall be issued only to shot-firers or to officials specially authorised in writing by the manager.

(*ii*) Shot-firers and other authorised persons shall keep all detonators issued to them until about to be used for the charging of a shot hole in a suitable case or box, securely locked, separate from any other explosive.

In the case of a shaft being sunk from the surface or deepened, it shall not be deemed a contravention of this section if the primers for charges are fitted with detonators on the surface before being taken into the shaft, provided the primers are so fitted in a workshop established under Section 47 of the Explosives Act, 1875, and are only taken into the shaft immediately before use by the shot-firer or other authorised person and in a thick felt bag or other receptacle sufficient to protect them from shock.

2.—(*a*) Every charge shall be placed in a properly drilled and placed shot hole, and shall have sufficient stemming, and each such charge shall consist of a cartridge or cartridges of not more than one description of explosive. It shall be the duty of the person firing the shot to satisfy himself that these requirements are fulfilled before he fires the shot.

(*b*) No iron or steel scrapers, charger, tamping rod, or stemmer shall be taken into or used in the mine; and only clay or other non-inflammable substances shall be used for stemming, and shall be provided by the owner, agent or manager of the mine.

(*c*) No explosive shall be forcibly pressed into a hole, and, when a hole has been charged, the explosive shall not be unrammed nor shall any part of the stemming be removed nor shall the detonator leads be pulled out.

(*d*) Before any shot is charged, the direction of the hole shall be marked on the roof or other convenient place.

(*e*) The person firing the shot shall, before doing so, see that all persons in the vicinity have taken proper shelter, and he shall also take suitable steps to prevent any persons approaching the shot. He shall also himself take proper shelter. If he has reason to believe that there is a possibility of the shot blowing through into an adjoining place he shall send verbal warning to the persons in that adjoining place to take proper shelter.

(*f*) No shot shall be fired in any coal mine except by means of an efficient mangeto-electrical apparatus or by means of a fuse complying with the conditions and ignited in the manner specified in the Third Schedule hereto.

(*g*) Where shots are fired electrically they shall only be fired by a person authorised in writing by the manager for the purpose. The authorised person shall not use, for the purpose of firing, a cable which is less than 20 yards in length. He shall himself couple up the cable to the fuse or detonator wires and shall do so before coupling the cable to the firing apparatus. He shall take care to prevent the cable coming into contact with any power or lighting cables. He shall also himself couple the cable to the firing apparatus. Before doing so, he shall see that all persons in the vicinty have taken proper shelter.

(*h*) Every electrical firing apparatus shall be provided with a push button, and with a removable handle which shall not be placed in position until the shot is required to be fired and which shall be removed as soon as a shot has been fired. The removable handle shall at all times remain in the personal custody of the authorised person whilst on duty.

3.—If a shot misses fire:—

(*a*) The person firing the shot shall not approach or allow anyone to approach the shot hole until an interval has elapsed of not less than ten minutes in the case of shots fired by electricity, and not less than an hour in the case of shots fired by other means.

(*b*) If he has occasion to leave the place, he shall fence off the place before leaving, and attach to each fence a danger-board indicating the presence of a miss-fired shot.

(*c*) A second charge shall not be placed in the same hole.

(*d*) If the shot was fired electrically, he shall disconnect the cable and the removable handle from the firing apparatus and shall examine the cable and connections for any defect.

(*e*) Except where the miss-fire is due to a faulty cable or a faulty connection, and the shot is fired as soon as practicable after the defect is remedied, another shot shall be fired in a fresh hole which shall be drilled not less than twelve inches away from the hole in which the shot has missed fire, and shall, as far as practicable, be parallel with it.

(*f*) If the miss-fired shot contained a detonator, the person firing the second shot shall, before doing so, attach a string to the electric leads or the fuse of the miss-fired shot, and secure it by attaching it to the cable or to a prop or otherwise.

(*g*) After the second shot has been fired no person shall work in the place until the person firing the shot or an official of the mine has made a careful search for the detonator and charge of the miss-fired shot. If the detonator and charge are not found, the stone or mineral shall be loaded under the supervision of the person firing the shot, or an official, and sent to the surface in a specially marked tub. The search for the detonator and charge, and the loading of any stone or mineral which may contain a detonator, shall be carried out as far as possible without the use of tools.

(*h*) Should the miss-fired shot not be dislodged by the second shot, further holes must be drilled, and the same precautions taken as aforesaid.

(*i*) The person or persons firing the shots shall report the circumstances to the manager or under-manager without

delay, and the number of cartridges, if any, which have not been found, and hand to him the detonator and charge, if found.

PART II.

4.—(*a*) In all coal mines in which inflammable gas has been found within the previous three months in such quantity as to be indicative of danger, no explosive, other than a permitted explosive as hereinafter defined, shall be used in or taken for the purpose of use into the seam or seams in which the gas has been found, or any shaft or drift communicating therewith which is in process of being sunk, deepened, driven, or enlarged, as the case may be.

(*b*) In all coal mines which are not naturally wet throughout, no explosive, other than a permitted explosive as hereinafter defined, shall be used in or taken for the purpose of use into any road or any dry and dusty part of the mine, or any shaft or drift communicating therewith which is in process of being sunk, deepened, driven, or enlarged, as the case may be.

5.—In all cases in which permitted explosives are required by this Order to be used:—

(*a*) A competent person (in this Order called a shot-firer), shall be appointed in writing by the manager of the mine for the purpose of firing shots. No person shall be so appointed if his wages depend on the amount of mineral to be gotten, and no person shall be qualified to be appointed or to be a shot-firer unless he has obtained the like certificates as to his ability to make accurate tests for inflammable gas, and as to his eyesight, as are required by Section 15 of the Act in the case of firemen, examiners, or deputies, and the provisions as to such certificates shall so far as applicable have effect as if incorporated in this Order.

(*b*) The shot-firer shall keep a daily record (in a book which shall be kept at the mine for the purpose in accordance with the provisions of Section 24 of the Act) of the number of shots fired by him, the number of miss-fired shots, if any, and the number of cartridges in each shot.

(*c*) No shot shall be fired in coal unless the coal has been holed to a depth greater than the depth of the shot-hole. This provision shall not apply to any anthracite mine.

(*d*) Every shot shall be charged and stemmed by or under the supervision of the shot-firer. Before the hole is charged the shot-firer shall examine it for breaks running along or across, and if any such break is found the hole shall not be charged, except in stone drifts if special permission has been given in writing by the manager or under-manager.

(*e*) No cartridge shall be used unless it is marked in the manner set forth in the Second Schedule hereto in addition to any mark required by the First Schedule hereto.

(*f*)—(*i*) No shot shall be fired except by the shot-firer.

(*ii*) No shot shall be fired unless the shot-firer has examined with a locked safety-lamp or other apparatus approved for the purpose by the Secretary of State the place where the shot is to be fired and all contiguous accessible places within a radius of 20 yards from the place, and has found them clear of inflammable gas.

(*iii*) No shot shall be fired unless the shot-firer has examined the floor, roof, and sides of all contiguous accessible places, within a radius of 5 yards of the place where the shot is to be fired, for coal dust, and has taken efficient steps to render any dust within that area harmless.

(*g*) Except in driving a stone drift or in sinking pits two or more shots shall not be fired in the same place simultaneously, and the shot-firer shall make an examination immediately before the firing of each shot, and shall not fire the shot unless he finds the place where the shot is to be fired and all contiguous accessible places within a radius of 20 yards free from gas and in all respects safe for firing. In stone drifts the number of shots which may be fired simultaneously shall not exceed three unless fired electrically in series.

(*h*) No shot shall be fired except by means of an efficient magneto-electrical apparatus so enclosed as to afford reasonable security against the ignition of inflammable gas.

(*i*) Each explosive shall be used in the manner and subject to the conditions prescribed in the schedules hereto.

6.—In the main haulage roads and main intake air-ways and any place immediately contiguous thereto in any coal mine which is not naturally wet throughout—

(*a*) No explosive shall be used other than a permitted explosive as hereinafter defined, and in accordance with the conditions prescribed by Clause 5 of this Order;

(*b*) No shot shall be fired without the special permission in writing of the manager or under-manager;

(*c*) No shot shall be fired unless the workmen have been removed from the seam in which the shot is to be fired, and from all seams communicating with the shaft on the same level, except the men engaged in firing the shot, and in addition such other persons, not exceeding ten in number, as are necessarily employed in attending to the ventilating furnaces, steam boilers, engines, machinery, winding apparatus, signals or horses, or in inspecting the mine.

PART III.

7.—The foregoing provisions shall apply in the case of sinking operations with the following additions:—

(*a*) No explosive shall be taken or sent into the shaft until immediately before it is required for use.

(*b*) No shot shall be fired except by means of an efficient magneto-electrical apparatus.

(*c*) The firing cable shall not be coupled up to the fuse or detonator wires until the kettle, kibble, tub, bowk, or hoppet is conveniently placed for the men in the shaft to enter, and the chargeman has received a signal from the surface that the engineman is ready to draw away on receipt of the signal to do so, and the cable shall not be coupled to the firing apparatus until all persons are in a place of safety.

(*d*) After a shot has been fired the chargeman shall not allow any person to descend until he has examined the place and found it to be safe in all respects. If the place is one in which inflammable gas has been found or is likely to be found, the examination shall be made with a locked safety-lamp.

8.—Where a mine contains separate seams, this Order shall apply to each seam as if it were a separate mine.

9.—A copy of this Order shall be supplied to every shot-firer, and a copy of the Order (with the exception of the First and Second Schedules) shall also be kept posted up in some conspicuous place at or near the mine where it may be conveniently read or seen by the persons employed.

10.—In this Order—

The term "permitted explosives" means such explosives as are named and defined in the First Schedule hereto, provided that where the composition, quality, or character or any explosive is defined in that Schedule, any article alleged to be such explosive which differs therefrom in composition, quality, or character, whether by reason of detorioration or otherwise, shall not be deemed to be the explosive so defined; provided, further, that an owner, agent, or manager shall not be responsible for the composition, quality, or character of an explosive, if he shows that he has in good faith obtained a written certificate from the maker of the explosive that it complies with the terms of the Schedule, and that he has taken all reasonable means to prevent deterioration of the explosive while stored.

The term "coal mine" includes mines in which coal is found, whether worked or not.

The term "road" includes all roads of any description extending from the shaft or outlet to within 10 yards of the coal face.

The term "main haulage road" means a road which has been, or for the time being is, in use for moving tubs by gravity or by mechanical power.

11.—This Order shall come into force on the 1st July, 1912, from which date the Explosives in Coal Mines Orders of the 21st February, 1910, 12th August, 1910, 10th October, 1910, 16th December, 1910, and 22nd April, 1911, are revoked.

12.—This Order may be cited as the Explosives in Coal Mines Order of May 21st, 1912.

Schedules specifying the permitted explosives, mark for same, and giving regulations as to fuses, accompany the Order.

Overwork a man, and when we squeeze the orange dry—what is left but the rind, and who gets it?

We may be the thumb on the hand of the world, but we cannot do without the fingers.

A dwarf is a giant among men smaller than himself, and this is about half there is of what we call fame.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Coal Cutting Machines.*

Laying Out the Workings.—At the outset it seems almost undesirable to point out that to attain any measure of success from coal-cutters and face conveyors, it is essential that the faces should be laid out in a "straight" line. One of the most important points is to lay out an "advance plan," after learning the local peculiarities and being satisfied as to the most suitable method of working. The advance plan should be constantly "kept up," and strict measures made to ensure the workings being made to fit the plan, unless prevented by unforeseen circumstances. The manager who studies his mine

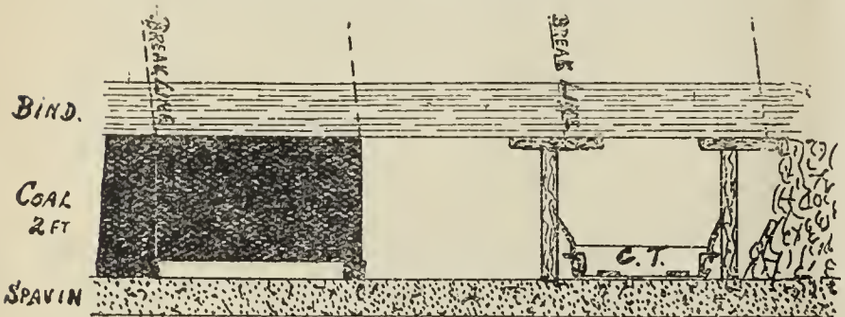


Fig. 1. Section of Work.

sufficiently will always have such a plan prepared, and he and his subordinates then know exactly what to do next. It is not intended here to lay down any ideal system, but simply to broaden ideas as to methods pursued, which methods may be made suitable for the particular seam under consideration only after experience and a study of the local conditions. With that in view none of the sketches herewith are drawn to scale, but are intended to give so much information as to be indicative of the best methods. The best results will be obtained when the coal face is laid out in a straight line, and long enough to allow the machines to cut backward and forward; the actual length of face, as indicated by *Figure 4*, being dependent on the extent of boundaries and local conditions. The coal-cutter and the conveyor should work in conjunction with each other, and the advantages claimed will thus be common to both machines, viz., "increased large coal, rapid advance of face, systematic timbering, increased safety, larger and more regular output at reduced cost."

Long straight coal faces of 1,000 or 2,000 feet, or even up to 4,000 feet, have been successfully worked, the faces being advanced "end-on," giving the maximum strength to resist pressure. The depth of holing by the machine may be 4 feet, 5 feet, or 6 feet, as past experience of the working of the seam by hand-holing may direct, or as trial experience by the machine has shown.

The conveyor may be of the Blackett type, which consists of 6 feet sections of sheet steel troughs, carried on similar lengths of angle iron framework. Each length is standardised, and made to be erected or dismantled by simply slotting together. Inside the troughs passes an endless chain of specially suitable design, to carry the coal along the troughs. The lower portion of the chain returns upon suitable runners, and a ratchet screw is provided at the tail end of the conveyor for suitably tightening or loosening the chain, as seen in *Figure 2*. Since the chain moves along the troughs, and coal is thrown on to the chain, it will be seen that the chain does two things—it carries the lumps of coal lying on it without scraping or breaking them, and it pushes along the very small coal which may fall to the bottom of the troughs when thrown on. The height of the conveyor itself over the troughs is about 10 inches. Of course, the discharging and the tail ends are a little higher than the troughs, but they easily go under 2 feet. The full width, overall, is about 18 inches along the face. The tail end is moored by chains secured to the timbers.

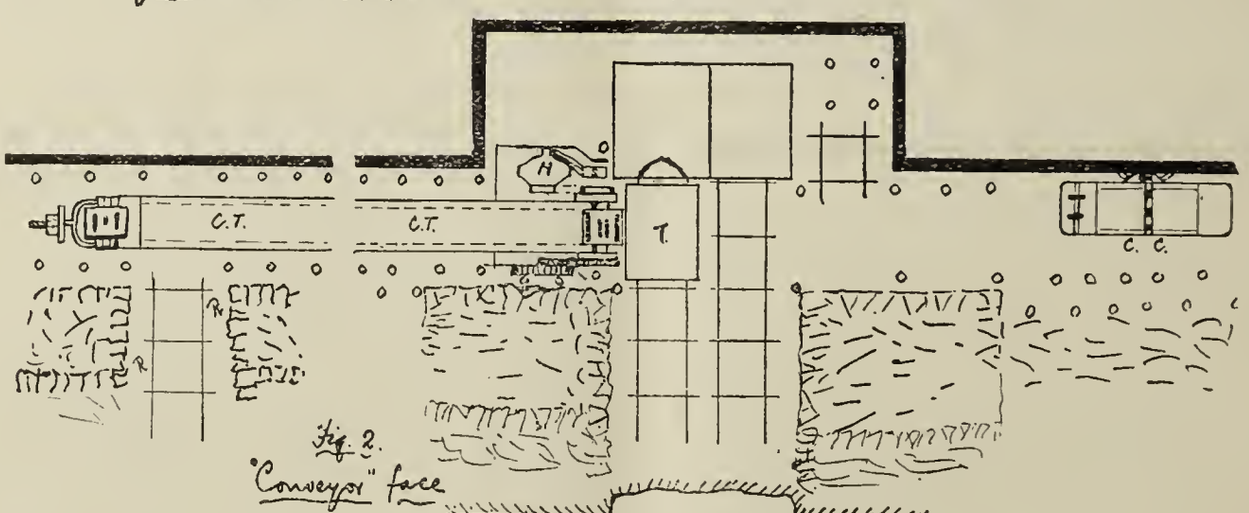


Fig. 2. "Conveyor" face

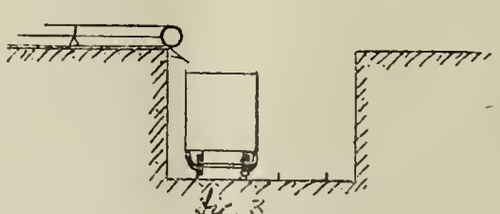


Fig. 3.

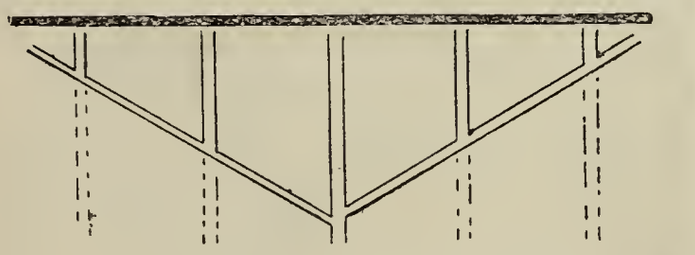
The best practical working length is about 90 yards. The discharging end comes into the main gate, which must be kept good with double road, and some arrangement for quickly getting the tubs under the trough-end, and keeping the conveyor supplied with tubs. *Figure 2* shows a plan of the arrangements, showing discharging end of trough, and "tailing and mooring end." *CT* represents the conveyor troughs, along which the coal is conveyed and discharged into the tub *T*. *Figure 1* represents a section of the work, showing the coal holed and ready for getting down, the conveyor shown in section being got up ready for the coal being thrown on. *Figure 3* represents section of main gate. *Figure 4* shows plan of district.

The method of working a face of work may be set out as

* See last issue.

follows: Coal-cutters start in the afternoon, say as soon as the coal has been filled away by the morning shift fillers; at night another set of coal-cutters goes on, and as the coal-cutter will be well along the face, men may commence to shunt the conveyor, commencing at the same end of the work as the machine-men began from. By the commencement of the morning shift, the coal-cutter will be through the length of holing, say 100 yards, into the "stable" at the other end. The conveyor shunters, following the coal-cutters, taking out and resetting the timber and pulling the conveyor troughs over by means of "Sylvester" timber drawers until they reach the other end of the face. The coal may then be blown down, broken up, and all ready for the morning shift to fill out. It is quite easy to so arrange the number of men as to get all the coal filled out during the morning shift. Mr. H. Baddeley, in a paper on "Working a Blackett Conveyor in the Working Face of a Thin Seam," read before the Yorkshire Branch of the National Association of Colliery Managers, gives the following description of the method of work adopted on a 100 yards face in a 2 feet seam:—

"A shift of coal-cutters goes on to work at 2 o'clock in the afternoon; at 10 p.m. another set goes on, also four men to commence shunting the conveyor. By 2 or 3 a.m. the coal-cutter is through into the other stable hole, having cut the whole of the 100 yards of face. The men have also removed the holing dirt to the gob side of the conveyor. The conveyor shunters, with the aid of "Sylvester" prop-drawers, get the conveyor shunted and completed by 6 a.m. The shot-firer then commences to blow down the coal, and the fillers, three or four in number, go on at 6 30 a.m. to break the coal up at different places. The other four fillers go on at 8 a.m., and the coal is usually filled away by 1 o'clock; in fact, eight men usually filled away the whole length of face in 4½ hours, the weight of coal produced being between 80 and 85 tons per fall. The fillers, in addition to filling the coal on to the conveyor, get up and



[*Figure 4.*]

remove from 3 inches to 5 inches of bottom dirt which has been left by the machine, and remove this dirt to the back side of the conveyor. Timber is set along the face as the coal is filled away." It is seen here that one conveyor and one coal-cutter, preferably a disc machine, will clear out one fall of coal on a face 100 yards long in one working day. If it is desired to work double this length, the main gate may be carried in the centre and arrangements made for a conveyor, and coal-cutter; at each side both conveyors can be arranged to discharge the coal into the same tub by taking the floor up in the main gate sufficiently to allow the tub to pass under the discharging ends and troughs. It will again be seen that any length of face, practically, can be worked on this system by carrying the "filling" gates from 180 to 200 yards apart, the cross-measure gates being "thrown" out as required to suit the length of face worked.

The advantages of such a system in a thin seam are many, but, of course, will vary according to the local conditions and natural circumstances of the seam. The advantages gained may be summarised as under:—

(1). Fewer men required on the face, as the output per man is greater, and in consequence less liability to accident and compensation payments.

(2). Better quality of coal, and a greater tonnage from a given area due to less waste.

(3). Less tramming and better haulage facilities.

(4). Less gates to keep open.

(5). Large tubs can be used with less arduous labour.

(6). System of timbering must be kept up in methodical manner, thereby giving less risk to the workers.

(7). Cost of production lessened throughout.

On the other hand, a conveyor could not be worked with very marked success in an undulating seam, or a seam with very tender roof, or a badly lifting floor.

Whilst conveyors necessitate systematic working and timbering, they certainly bring about one or two fresh dangers, the principal one of which is that by placing a conveyor in the coal face, "the face itself is made into a haulage road." Again, both the coal-cutters and conveyors generally produce a fairly large quantity of dust, which must be recognised, especially in dry and dusty mines, and also in the face of the fact that heavy shots are necessary to break down the coal. Another very objectionable point in connection is the noise made by the conveyor.

So far as power is concerned, electricity may be used, if the stringent electrical order will allow such with safety, or compressed air might be used. For many reasons the latter is preferable, especially when one considers the dust raised. The actual power required by a Blackett conveyor, 90 yards long, is about 8 to 10 B.H.P., and both electric motor or air engine are arranged and designed as to form part of and move with the conveyor, requiring no special erection. If electric power *can* be safely used for the coal-cutting machines it is clear that the same power can be used for the conveyors. It is certain that the electrification of collieries is proceeding apace, and every means is being utilised to make electricity quite as safe in operation as other motive powers. So far as the dust is concerned, if the cutting machines can do their work in the stone or dirt underlying the seam, then the coal face becomes a "stone-dust zone," with its consequent alleviation of danger.

EXAMINATION RESULTS

The following is a list, communicated by the Home Office, of the successful candidates at the Examination held in the Liverpool and North Wales District on the 11th, 12th, 13th and 14th June, 1912, to whom Certificates of Competency as Managers or Under-Managers of Mines have been granted under the Coal Mines Regulation Act, 1887:—

First Class (*Managers*): William Thomas Barnes, Harry Hargreaves Bolton, Charles Huntley Dixon, John Mark Livingston Hess, Athole Frederick Holden, William Thomas Emmett Malbon, James Gordon Mein, Joseph Pease, John Wilfrid Talbot, Ralph Unsworth, John Walker.

Second Class (*Under-Managers*): Solomon Ainscough, Wilfred Ashton, Thomas Ashurst, William Atherton, Matthew Alexander Balfour, William Battersby, William Beardsmore, George Beck, George Bennett, Joseph Brogan, Arthur Bullock, Henry Calland, Thomas Chadwick, William Chapman, John Charnock, John Cheetham, Leonard Colclough, Thomas Croft, Elijah Crompton, George Cross, Henry Cross, John Cross, Joseph Cunnah Daniel Darlington, William Dearden, Junr., James Eaves, Henry Enion, William Farmer, Arthur Farnsworth, George Fearnley, Harry Foxley, Mark Gabbitas, John Ganderton, John Edward Gaskell, Thomas Gaskell, Herbert Gent, Joseph Glover, Matthew Hamblett Gore, John Ethelbert Graves, James Green, Moses Aspinall Greenall, Thomas Gregson David Griffiths, David Grundy, Richard Grundy, Robert Grundy, Samuel Hodgkiss, Fred Hartley, Abraham Hill, William Thomas Holland, George Trevor Hollingworth, James Hollinshead, Samuel Hough, John Hunter, Joseph Hunter, Thomas Hurst, George Jackson, Thomas James, Arthur Jones, Edwin Jones, Thomas Jones, James Judge, Frederick Lee, James Lee, Arnold Lowe, Randle Henry Lunt, John Lyons, Thomas Marshall, George Meadows, James Mercer, Robert Millington, Alfred Mills, Edward Mitchell, Robert Morgan, Thomas Owens, James Pemberton, Edward Pilkington, William Robinson, Daniel Simpkin, Albert Smith, Harry Smith, Richard Smith, Henry Speak, James Speakman, James Stretch, Thomas Francis Tattum, James Waddilove, William Walker, Richard Weston, Luther Westwood, John William Wilton, Edward Winfield, Robert Winstanley, Ernest Yeum.

THE MINERS' PRESIDENT.

Death of Mr. Enoch Edwards, M.P.

We regret to record the death at Southport on Friday, June 28th, of Mr. Enoch Edwards, president of the Miners' Federation of Great Britain, and M.P. for Hanley.

Born at Talk-o'th'-Hill on 10th April, 1852, Mr. Edwards entered the mine when barely nine years of age. Nine years later his position at the pit amongst other duties comprised that of actual haulage of coals, work now properly delegated to animals or machinery. He described the operation as one of slavery, but at the age of 19 Mr. Edwards blossomed into an actual hewer of coal, in which position he gathered many experiences as to inundations of water and accumulations of gas that proved invaluable later in assisting actively in legislation. It will be recalled that he represented the miners on the Royal Commission on Mines, whose report was followed by the new Mines Act.

Mr. Edwards rendered yeoman service in friendly society work. He was district secretary to the Loyal Order of Ancient Shepherds in 1887, and during his term of office the members in the district advanced from less than 700 to nearly 2,000, and the funds in hand from £2,000 to £10,000. Upon retirement from the office his services were duly recognised.

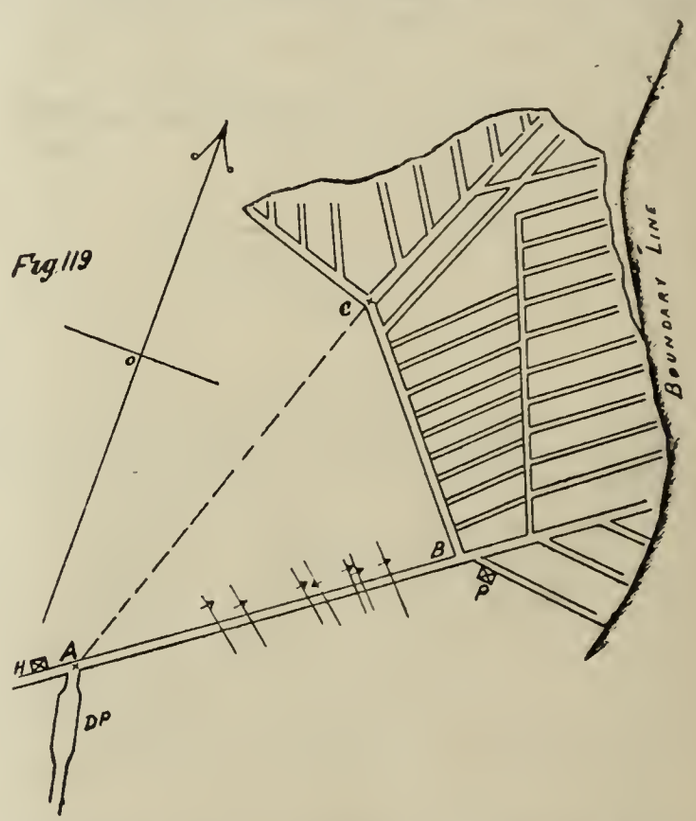
The year 1884 saw him discharging the duties of miners' secretary, and it began to be recognised that as a leader he was sound and efficient; even proprietors were wont to refer to him as a fair man. In regard to this the late Mr. Percy once expressed himself thus: "I do not know that any of us could wish for higher praise, that we are faithful to our friends and fair to our opponents; the hardest fighters are the fairest opponents." We find that in 1888 Mr. Edwards was chosen to be treasurer of the newly formed Miners' Federation; afterwards on the death of Mr. Pickard in 1894 becoming its president. He was very active in municipal affairs in the pottery district. In 1886 he was returned to the Town Council of Burslem, and in the same year was elected to the School Board. When elected member for Hanley in 1906 he retired from municipal life, being then an alderman and ex-Mayor. Before the fusion of the miners with the Labour Party Mr. Edwards was chairman of the trade union group in Parliament.

Those who knew him best knew that he would undertake nothing to which he felt he could not give the attention and energy that the work required. This was one of the characteristics of the man. He was extremely modest and absolutely sincere, a thing that was manifested whenever he made any of his few public speeches. His death is a loss not only to the Miners' Federation, whose course he guided with such remarkable efficiency, but also to labour organisation as a whole. He was not a platform speaker, but his strong common sense and his absolute reliance on the strength of character of working men and women carried conviction with them. Mr. Edwards was for eight years the president of the International Federation of Miners, and was chairman of the meetings both in England and on the Continent.

SURVEYING.

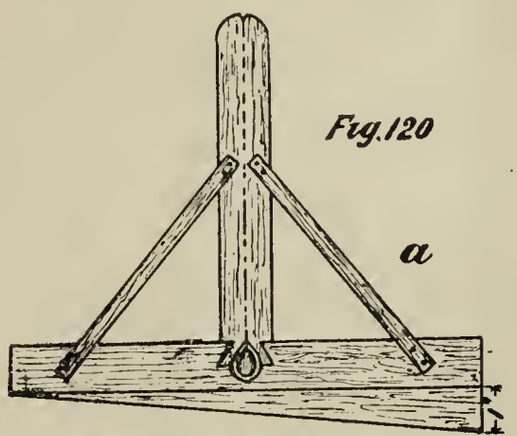
By COLLIERY SURVEYOR.

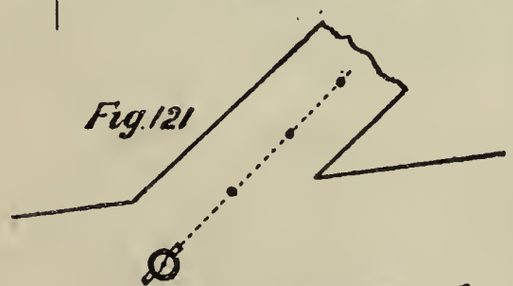
Setting out a Drivage in a given direction and at a certain Inclination.—Consider *Figure 119*. *AB* is a dip plane 200 yards long, passing through faulty ground at a gradient of 3 inches per yard. From *B* to *C* is about 170 yards, and the average rise is 5 inches per yard. *P* is a pump which delivers a considerable volume of water at *A*; *H* is the hauling engine for the plane *AB*; *DP* is a pass bye or double parting. The power expended in hauling and pumping is a serious drain on the profits of the colliery. A series of levels taken from *A* to *B* and thence to *C* reveal the fact that *C* is 20 feet 10 inches vertically higher than *A*. The dip workings are nearly exhausted and the boundary line goes round to the right. A road driven from *A* to *C* will ensure for the future free drainage

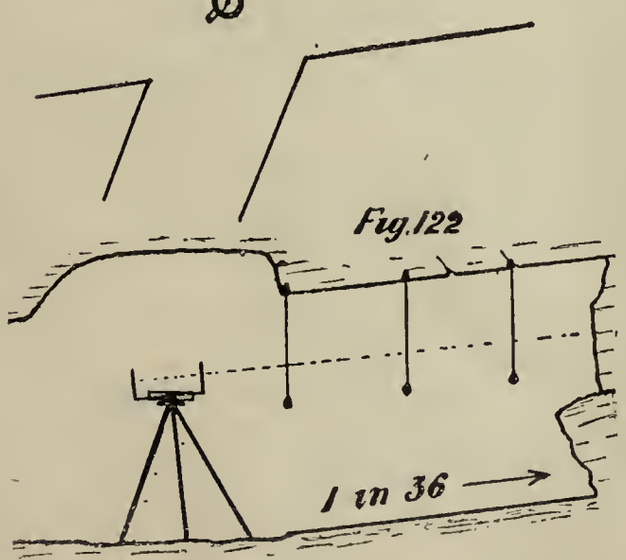


and easy haulage. The pump at *P*, and probably also the haulage at *H*, will be no longer necessary. It is therefore decided to proceed with the work. The surveyor draws a pencil line connecting *A* and *C* on the plan. He parallels this line on to the point of intersection *O* on the magnetic meridian, and draws a line passing through the point. Placing the protractor thereon he ascertains that from *O* in a N.-Easterly direction the bearing of the line is N18°E. This means that from *A* the point *C* is in a direction N18°E. Since it is necessary that the drivage be made with the utmost dispatch, the surveyor notes also that the S.-Westerly direction of the line reads S18°W. This means that from *C* point *A* is in a direction

S18°W. The exact positions of *A* and *C* having been fixed, men are set to work at both points to drive a few yards in the probable direction. This done, a direction line becomes necessary. The surveyor proceeds to the position *A*, plants his instrument, unclamps the needle, searches for and removes any possible source of attraction, and allows the needle to come to rest in the meridian. The dial sights are now turned until the needle reads exactly N18°E. This is the required direction. A string carrying a plummet is suspended from the roof at a point near the face, steadied, and then sighted to. To show







the string clearly a light, shaded by the hand from the observer, is held close to it, or a piece of tracing cloth with a light held behind it forms a very nicely illuminated background. The string can thus easily be seen, the positions respectively from the instrument being string, tracing cloth, lamp. The string is moved as directed by the surveyor until it is exactly coincident with the dial sight produced. A chalk mark is made on the roof at this point, and a hole is bored to receive a wooden plug. Another sight is taken to fix the exact point at which a staple, nail or cramp must be driven into the plug for the support of the string. The procedure is precisely the same at two other points nearer the instrument, as shown in plan, *Figure 121*, and in section, *Figure 122*. Any two of these lines may be taken for the guiding of operations at the face, a light being held at that point while the responsible person stands behind the outermost string and sights along the two strings to the face. Three strings are useful in case one is lost by some accident, such as a breaking of the roof at such point. The third string is also useful as a check to detect lateral displacement of any one of them from the same straight line. In such case the surveyor should be advised so that he may determine once more the correct direction. In general such displacement will only happen where the plumb lines are hung from nails driven into the roof timbers. From time to time as the drivage proceeds, the surveyor will move the sight lines forward to within a reasonable distance of the face. The procedure at *C* is identical to that already described, except that the direction, instead of being N18°E, is S18°W.

As to Gradient.—By scaling off the plan the horizontal distance *AC* is found to be (say) 250 yards, so that with a difference of level of 250 inches between these points the drivage will rise from *A* to *C* at 1 inch per yard, or 1 in 36, with a corresponding drop from *C* to *A*. T-bobs will be necessary to maintain the proper gradient. The construction will be clear from *Figure 120, a* and *b*. The V-shaped notch at the top of the T has also a saw cut which secures a piece of whipcord which carries at its lower end a leaden plumb bob. Provided the vertical leg is fitted exactly at rt. ∠s or ⊥ to the bottom part, then, when the latter is laid truly horizontal, the plumb bob will swing clear in the centre of the aperture provided for it at the bottom of the vertical leg. Let this horizontal piece be 1 yard long. It is required to use the T-bob on a gradient of 1 inch per yard. Let a strip of wood tapering from 1 inch to nothing be fixed on the under side, as shown in *Figure 120, a*. This means that when the T-bob is itself horizontal the right under side is 1 inch lower than the left, and by its use the rails laid in the drivage may be adjusted to the exact gradient. Whatever the gradient it is therefore only necessary to fix a piece of the required width on the under side; even as at *b*, which is the method sometimes adopted. Thus for 4 inches in the yard or 1 in 9 the width or depth of the piece will be 4 inches. Sometimes the horizontal arm of the T is made in one piece, so that if the arm in *Figure 120* is 4 inches wide or deep, the right-hand side will be 5 inches, sloping down to 4 inches at the left side. For a rise drivage the thinner or shallower end must be in front, while for a dip drivage the thicker or deeper end must lead. A mistake on this point is likely to occur only when gradients are slight, such as $\frac{1}{8}$ inch or $\frac{1}{4}$ inch in the yard. Should great importance attach to the accuracy of the gradients a further check can be provided by the theodolite taking the ∠ of elevation or depression at certain intervals during the driving. Or the dumpy level may be used for the same purpose. It is only necessary to construct a T-bob accurately, not elaborate, but strong, because it is more than probable that in the course of driving a cross-measure drift it will need repeated repairs owing to damage caused by flying stones, falls of roof and side, &c.

EXPLOSIVES ACT.

In their annual report, the inspectors under the Explosives Act state that during last year the number of accidents caused by explosives in this country was 515, resulting in 56 deaths and injuries to 548 persons. In 1910 the total was 450, the fatalities numbering 66, and the persons injured 442. As many as 93 per cent. of the accidents causing loss of life or personal injury in 1911 occurred in the use of explosives, there being only 33 such accidents in connection with their manufacture, storage, and conveyance. In the 4,021 accidents recorded during the last ten years, 562 persons have been killed and 4,178 injured.

Common sense and less bulldozing would save the world half its labour troubles.

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GLAMORGAN COUNTY COUNCIL.

APPOINTMENT OF LECTURER IN MINING.

The Education Committee Require the Services of a MINING LECTURER.

The candidate appointed must be qualified to teach the subjects of the Glamorgan Mining Course; must reside where directed by the Committee, and devote his whole time to his duties.

Salary, £150 per annum, rising by annual increments of £10 to a maximum of £200 per annum, together with travelling expenses according to scale.

Canvassing directly or indirectly will disqualify.

Applications, made on forms which may be obtained on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, COUNTY HALL, CARDIFF.

The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, JULY 6, 1912.

THE COAL MINES ACT, 1911.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

Supporting Roof and Sides.

Section 49.—The roof and sides of every travelling road or working place shall be made secure, and a person shall not travel on, or work in, any travelling road which is not so made secure.

An exception is made in the case of a person appointed for the purpose of exploring or repairing such roadways.

Systematic Support of Roof and Sides.

Section 50.—(1). Where props, *or* props and bars, *or* chocks, are used to support the roof at the working face, the roof under which any work of getting coal is carried on, *or* under which any filling tubs is carried on, shall be systematically and adequately supported.

(2). Holing props or sprags shall be set as soon as practicable. They shall be set in a manner specified by the manager. They shall not be removed until the coal is about to be taken down, *nor* until the roof has been supported in a manner as specified under sub-section (4).

(3). In all parts of a roadway in which sets or trains of tubs consisting of three or more tubs, are coupled or uncoupled, the roof and sides shall be systematically and adequately supported. In all parts of a roadway requiring props or bars for support, such props or bars shall be set at regular intervals in a specified manner.

(4). The manager shall issue a notice specifying the manner in which supports shall be set and advanced.

This notice shall specify the maximum distance between supports on the roadways.

For supports at the face it shall specify the maximum permissible distance—

(*a*) between each row of props;
(*b*) between adjacent props in the same row;
(*c*) between the front row of props and the face;
(*d*) between the holing props or sprags;
(*e*) between chocks.

In no case shall the interval between holing props or sprags be greater than 6 feet.

(5). If the Divisional Inspector of Mines considers any particular system to be unsatisfactory, he may request the manager to modify the system.

(6). This section does not apply to any mines in which the conditions are similar to those existing in the Thick Coal district of South Staffordshire, or in the Cleveland stratified ironstone mines.

(7). If, in order to secure safety, a workman considers it necessary to set supports at distances apart, *less* than those specified in the notice, he is at liberty to do so.

Supply of Props and Bars.

Section 51.—Where workmen erect their own supports, a sufficient supply of materials shall be kept at or within *ten yards* of every working place, *and also* at the pass-bye, siding, or other similar place convenient to the workmen.

It shall be the duty of the *firemen, examiners, or deputies* to see that such sufficient supply of timber is kept. A place in which the supply of timber is insufficient shall not be considered safe for the purposes of the Act.

A sufficient supply of timber to enable firemen, examiners, or deputies to carry out these duties shall be constantly provided.

Provision of Timber.

Section 27.—(1). In *every* mine, the materials required for the support of roof and sides shall be provided *by*, and at the cost of, the owner of the mine, notwithstanding that the work or any part of the work is carried on by a contractor.

Withdrawal of Supports.

Section 51.—(1). If, in any part of the mine, it is found necessary to withdraw any roof supports, previous to doing so temporary supports shall be set so as to secure the safety of the persons employed.

(2). If props require to be withdrawn it shall be the duty of the *fireman, examiner, or deputy* to carefully examine the roof which these props support.

If, in his opinion, the roof is sufficiently safe, he may permit the props to be withdrawn without the use of a safety contrivance.

No prop shall be withdrawn *without* a safety contrivance from under *any* roof, unless the sanction of the *fireman, examiner, or deputy* has been obtained.

Travelling Roads and Haulage.

Section 42.—(1). For every seam in a *new* mine (unless specially excepted), there shall be provided two main *intake* air-ways. Both of these shall be maintained in a condition affording a ready means of passing to or from the workings.

One of these intake air-ways shall *not* be used for the haulage of coal.

General regulations shall be made under this Act for determining exceptions from the foregoing provision.

If the number of persons underground at any one time is less than 100, it is not necessary to have two intake air-ways.

A mine naturally wet throughout is also exempted from this provision.

(2). For every seam in *any* mine there shall be provided two main air-ways in such a condition that they can be used for travelling. (One of these may be the return).

In a mine exempted, under sub-section 1, from having two *intake* air-ways, it is still necessary to have *two* air-ways in a fit state for passing to or from the workings without difficulty.

(3). In every mine *or seam*, opened after July 1st, 1912, all stoppings between main intake air-ways and main return air-ways shall be constructed in a manner specified in general regulations. These general regulations shall also specify the manner in which air-crossings shall be constructed.

So far as is practicable these stoppings and air-crossings shall be constructed so as to resist the force of an explosion.

(4). In any mine or *seam* opened since December 16th, 1911, the main return air-way cannot be used as a haulage road for coal if it is found normally to contain more than *one-half* per cent. of fire-damp.

Coal obtained in repairing or enlarging this air-way may be hauled through it during repairs.

It is permissible to have more than one-half per cent. of fire-damp in any return used for haulage, within 300 yards of the upcast shaft.

(5). In mines newly opened after July 1st, 1912, the main air-ways shall be arranged in a manner required by the regulations of the mine, and the connections between the air-ways shall not be less than the minimum distance specified in those regulations.

Section 45.—(1). Every travelling road shall be of adequate height, to the reasonable satisfaction of the Divisional Inspector of Mines.

(2). Every road through which a horse has to pass shall be large enough to allow it to do so, without rubbing itself or its harness against the roof or sides or the bars or props supporting the roof or sides.

Section 47.—Every haulage road shall be kept clear as far as possible of pieces of coal and other obstructions.

Section 48.—Every haulage road on which persons travel shall be provided with a proper system of signalling, if the haulage is worked by gravity or by mechanical power, provided the roadway exceeds 30 yards in length.

The system of signalling adopted must permit of distinct and definite signals being given between all regular stopping places and the ends of the road.

Travelling on Haulage Roads.

Section 43.—(1). After January 1st, 1914, it shall not be lawful for any person (unless he is an official, a person employed on the haulage, or a person doing urgent repair work) to travel any haulage road containing haulage worked by gravity (that is, worked on an incline by the weight of the full tubs), nor on any haulage road containing mechanical haulage if such haulage is in motion, unless certain requirements are fulfilled.

(*a*) In all cases the rate of haulage must be less than 10 miles per hour.

It is permissible to travel a haulage road during motion, provided the rate of haulage is not more than 10 miles per hour, *and* that there is a clear space of at least two feet between the tubs and the supports (if any) on *one* side of the roadway.

(b) If a clear space of two feet is *not* provided at one side of the road, and it is desired that workmen should travel the road, the maximum speed of haulage permissible is 3 miles per hour; the gradient of the roadway if it exceeds 100 yards in length, must not exceed 1 in 12, or 3 inches per yard, and the space between the tracks of rail must be free from obstructions.

If a roadway is less than 100 yards in length the gradient may be 1 in 9, or 4 inches per yard.

If the clear space required under sub-section (*a*) has been reduced in parts by uncontrollable causes, exemption may be granted during such period as may reasonably be required for repairs.

(2). Where the haulage is worked by gravity or by mechanical power, no person shall be allowed to ride on sets or trains or tubs, with the following exception:—

(*a*) A person may travel on a set of tubs for the purpose of detaching or attaching tubs from or to the haulage rope, provided the speed during the journey does not exceed 3 miles per hour.

(*b*) With the written consent of the manager *or* under-manager, men may be conveyed to or from their work at the *commencement or end* of their employment on a set or train of tubs.

(*c*) The driver of a locomotive is permitted to ride.

(3). In all places where sets or trains of tubs consisting of three or more tubs are coupled or uncoupled, there shall be a clear space of at least two feet between tubs standing on any rails and the side of the road nearest to those rails.

(*a*) In double roads the clearance space may be provided at the centre of the roadway instead of at the sides.

When this method is adopted there must be a *clear* space of at least *three* feet between tubs standing on the rails.

(*b*) An exemption may be granted to any existing mine where the requirements of sub-section (3) would necessitate the removal of masonry, and to any mine in which other provisions have been adopted in accordance with the general regulations of the mine.

Sub-section (3) shall come into operation on January 1st, 1913.

The Secretary of State may grant an exemption from this sub-section to any district in any mine which, in his opinion, will be worked out before July 1st, 1915.

(4).—In measuring the clear spaces mentioned in this section, props or other supports projecting beyond the side of the road shall be deemed to form part of the side.

[NOTE.—It will be necessary when setting timber in roads to which this section applies to have a clear space of at least 2 feet between the side of the *tub* and the *inward* or roadward side of the props, except in those cases where the clearance space is provided in the centre of the road.]

Refuge Holes.

Section 44.—(1). Every haulage road on which the haulage is worked by gravity or mechanical power shall be provided with refuge holes.

If the gradient exceeds 1 in 20, the refuge holes shall be at intervals of not more than 10 yards.

If the gradient is 1 in 20 or less, *and* a clear space as defined in Section 43 (1) is provided, it will be sufficient if the refuge holes are not more than 20 yards apart. If such clear space cannot be provided, and the gradient is 1 in 20 or less, the refuge holes may be not more than 20 yards apart, *provided* the rate of haulage is not more than 3 miles per hour.

(2). If horse haulage alone is worked on any road the refuge holes shall be at intervals of not more than 25 yards.

(2). (*a*) Every refuge hole shall be as near as may be three feet in width and not less than four feet in depth.

(*b*) Every refuge hole shall be not less in height than the height of the haulage road at the point where the hole is. In high roadways the refuge holes need not be more than six feet high.

(*c*) If a clear space is provided (sec. 43) every refuge hole shall be on the same side of the road as the clear space.

(*d*) If a clear space is not provided every refuge hole shall be on the same side as the other refuge holes. (They shall all be on the same side). Where the road is on a curve, the refuge holes shall be on the *outer* side of the curve.

(*e*) Every refuge hole shall be marked with a distinctive number.

(*f*) If necessary to make it readily visible, every refuge hole shall be constantly kept whitewashed inside, and also for a distance of not less than one foot round the aperture.

(*g*) Every refuge hole shall be kept clean.

(4). Nothing shall be placed in any refuge hole or across the entrance thereto.

(5). Refuge holes are not required on any road within 25 yards of the working face.

Apparatus on Haulage Roads.

Section 46.—(1). Every capped haulage rope must be re-capped at intervals of not more than 6 months.

(2). A sufficient supply of suitable sprags, lockers, or drags shall be provided and used

(*a*) at the top of every self-acting incline;

(*b*) at every place where sets or trains of tubs are coupled or uncoupled, provided there are three or more tubs in the set;

(c) at all roads, or *parts of roads*, worked by anima,l power if the dip is more than 1 in 20.

(3). Stop blocks shall be provided at the top of every self-acting incline.

They shall also be placed at every entrance admitting tubs to such incline.

(4). (*a*). If the dip exceeds 1 in 12, and mechanical haulage, other than endless rope or endless chain, is used, such roads shall be provided with runaway switches to prevent accidents in the case of runaway tubs.

(*b*) On such roads there shall also be provided and attached to an ascending *tub* or set of tubs a suitable backstay to prevent the tub running back.

(*c*) When persons are being conveyed in tubs on such roads, over-chains, bridle chains, or other suitable appliances shall be provided to prevent the tubs becoming disconnected and running away.

Prevention of Coal Dust.

Section 62.—In every mine, unless the floor, roof, and sides of the road are naturally wet *throughout*—

(1). Arrangements shall be made to prevent screen dust from entering the mine.

(2). The tubs shall be so constructed and *maintained* that coal dust cannot escape through their sides, ends, or floors.

(3). The floor, roof, and sides of the roads shall be systematically cleaned so as to prevent, as far as practicable, the accumulation of coal dust.

(4). Systematic steps shall be taken to prevent the occurrence of coal dust explosions or their extension along the roads.

The procedure to be adopted will be specified in the regulations of the mine.

(5). The roads shall be examined daily. A report of this examination shall be recorded in a book for the purpose.

The report shall state the condition of the roads as to dust, and the steps taken to mitigate danger arising therefrom.

Machinery, etc.

Section 55.—Every flywheel and all exposed and dangerous parts of machinery used in or about the mine shall be kept securely fenced.

Section 57.—(4). Where on any haulage road the haulage is effected by means of machinery worked by mechanical power, by animal power, or by manual labour, the person in charge of such machinery must be a competent person not less than 18 years of age.

Section 66.—(*b*) Competent persons appointed by the manager for the purpose shall at least once in every week examine thoroughly the state of all machinery used below ground.

(*d*) Competent persons shall once at least in every week examine *thoroughly* the state of *every* air-way in the mine. Full and accurate reports of these examinations shall be made by the persons making the examinations, and shall be signed by them.

These reports must be accessible to the workmen.

Water and Bore-holes.

Section 68.—Where any working has approached within 40 yards of a place containing or *likely to contain* an accumulation of water or other liquid matter, the working shall not exceed eight feet in width.

A similar maximum width is fixed when approaching disused workings which have not, *by examination*, been found to be free from accumulation of water or other liquid matter.

Near the centre of such working a bore-hole shall be kept in advance, a distance of not less than 5 yards, and there shall be sufficient flank bore-holes on *each* side, at intervals of not more than 5 yards.

Storage of Materials, etc.

Section 69.—(1). No oil, grease, *canvas*, or other highly inflammable material shall be stored below ground, except in a fireproof chamber.

(3). No inflammable material likely to cause danger from fire shall be used in the construction of any engine house below ground.

Section 70.—At all parts of a mine where *timber*, grease or other inflammable material is stored, adequate means of extinguishing fire shall be provided.

General and Special Regulations.

Section 86.—(1). The Secretary of State may by order make general regulations for the conduct and guidance of persons acting in the management of mines, or employed in or about mines. These regulations will be such as may appear best calculated to prevent dangerous accidents, and to provide for the safety, health, convenience and proper discipline of the persons employed in or about mines, and for the proper care and treatment of horses.

(2). The regulations made under such order may apply to all mines or to any specified class of mines.

(4). An order made under this section shall have effect as if enacted in the Act.

Section 87.—(1). Where the inspector of the division considers that the general regulations made under Section 86 ought to be supplemented or modified with respect to any mine, he may formulate special regulations for that mine, and send them to the Secretary of State for his approval.

In a similar way the owner of the mine may ask for the approval of special regulations.

If a majority (ascertained by ballot) of the workmen in any mine consider that the general regulations ought to be modified, they may send for the approval of the Secretary of State special regulations for that mine.

(3). When special regulations have been approved by the Secretary of State, they shall have effect as if they formed part of the Act.

Section 89.—(1). The "regulations of the mine" (referred to in various sections of the Act) means the general and special rules made under sections 86 and 87 applicable to that mine.

[Note.—In addition to the Act as such, it is necessary that all firemen, examiners, or deputies should become acquainted with the general and special regulations made under the above sections, and all orders which may from time to time be issued by the Secretary of State. These will apply as if they were part of the Act.]

Copy of the Abstract of the Act and Regulations.

Section 88.—(1). (*b*). When a person commences employment in or about any mine he shall be *given* a book containing so much of the Act and the regulations of the mine, as may affect him in his employment.

On each occasion a new abstract is issued or new regulations made, a prescribed copy shall be given to each person affected.

Any person employed in a mine may at any time obtain for one penny a copy of this book of abstracts by applying to the office at which he is paid.

"Mining Law."—Regarding your query, all previous Acts referring to the *safety* of mines are repealed by the Coal Mines Act, 1911. As explained in Section 126 and the fourth schedule, Special Orders will be made in accordance with the provisions of Section 86 which you will observe are exceedingly wide. The chief Orders already made refer to the use of electricity in mines, rescue brigades, and the use of explosives. Innumerable others may be in existence before this is in print. Mine-owners are subject to all laws relating to employer and employed, such as laws referring to contract, and truck, the Employers' Liability Act, the Workmen's Compensation Act, the Insurance Act, and in addition have their own Eight Hours Act and the Minimum Wage Act, with all its local regulations and exemptions, &c. If you contemplate specialising in Mining Law you have my sympathy.—M. E.

[Note.—In this attempt to simplify the reading of the Coal Mines Act, as it affects firemen, examiners, or deputies, it is possible that some errors of interpretation have crept in, and some omissions made. Should any such be noticed the writer would be obliged by having his attention drawn to them. Letters may be addressed to M.E., care of *The Science and Art of Mining* Office, Wigan.]

PRIZE COMPETITION.

"Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXII.

In this column we give *Twelve Questions* in each issue—four Preparatory, four Second Class or Under-Managers, and four First Class or Colliery Managers. The competition is open to all who have not secured first place in Honours or First Class in earlier volumes, and competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of One Shilling. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer, with the question attached, must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches (wherever they are desired they should be given) must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript.

The answers submitted by Competitors will be awarded marks according to order of merit. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks*; whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. At the end of the volume the total marks obtained by each Competitor throughout the volume will be added together to ascertain the three Competitors in each stage whose work has in general been distinguished by the highest degree of merit. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured.

The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

Then in addition to the prize awarded each issue for each successful answer in each stage, we offer the following special prizes:—We shall give Book Prizes to the three competitors who have in the aggregate obtained or been awarded the highest number of marks on the answers submitted for competition during the volume in the Preparatory Stage; also three in the Second Class and three in the First Class. The photo of the most successful of the three First Class men will be published, and he cannot take part in the Competition of later volumes. The Editor will give—in addition, of course, to the Publishers' prizes—special prizes to the best student in each Stage; the students will be allowed to make their own selection, the value in the case of the Editor's prizes being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, July 16th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the head of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[In all cases where quotations or extracts are made the source and authority must be stated. The selected answers to the following questions will appear, not in No. 25, Vol. XXII., but in No. 26, Vol. XXII.]

PREPARATORY.

Q. 1 BAROMETERS.—*Describe the principle of the barometer.*

Q. 2. VENTILATION.—*How is an air-current produced?*

Q. 3. LAMP-ROOMS.—*Give a general description of the lamp-room fittings, cleaning and repairing of safety-lamps.*

Q. 4. EXPLOSIVES.—*How would you use gunpowder in wet places?*

SECOND CLASS.

Q. 5. PUMPS AND PUMPING.—*What advantages has the plunger over the bucket lift?*

Q. 6. STEAM.—*Describe the different stages involved in the conversion of water into superheated steam, carefully noting the changes of temperature and volume.*

Q. 7. WINDING.—*What is the negative load of a winding engine, and when does it occur?*

Q. 8. METHODS OF WORKING.—*What special dangers attend pillar workings, and how should they be provided against?*

FIRST CLASS.

Q. 9. COALS.—*What are the qualities required in a steam coal for navigation purposes? Where are such coals produced in the United Kingdom, and how are they prepared for sale?*

Q. 10. PUMPS AND PUMPING.—*What arrangements are necessary for renewing the wearing parts of mine pumps, and generally for keeping the pit work in order?*

Q. 11. SPONTANEOUS COMBUSTION.—*When a coal seam is on fire underground, how should it be isolated to prevent the fire from spreading to other parts of the workings?*

Q. 12. SURVEYING.—*What errors in direction are likely to arise from surveys made with the magnetic needle, and how can such errors be controlled and corrected?*

Best Answers Received to Questions In No. 22, Vol. XXII.*

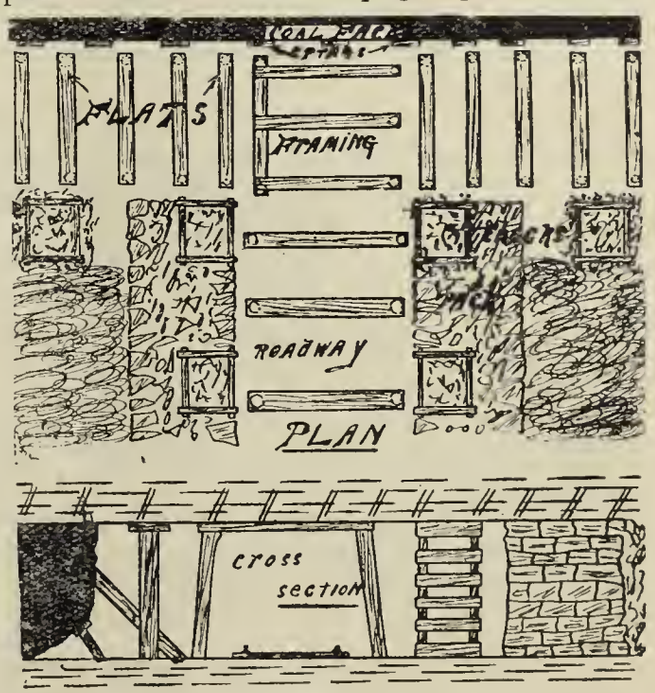
With Notes by C.C.M.

PREPARATORY.

Timbering.

Q. 1.—*Give your views on the question of timbering at the working face in a seam about 6 feet in thickness.*

A.—Timbering is a work that requires the best attention possible. In all cases there should be a proper system in vogue to suit the conditions peculiar to the seam of coal that is being worked. Of course, in drawing up a proper code as to the maximum distance apart of roof supports and the methods of timbering to be adopted, the nature of the roof and floor, the thickness and inclination of the seam, are the chief factors requiring consideration. In a highly inclined seam the method adopted would be in the form of sprags, especially if the seam



Illustrating Question 1.

is soft and tender. In many seams worked on the long wall principle and in the bordway direction there is a great tendency for the coal to fall off in thick slabs, and it is essential, in order to prevent accidents, that all overhanging coal be adequately spragged, and the maximum distance apart of sprags as stipulated in the rules *not* taken as the minimum, as is often done.

If the roof is hard and the floor soft the timbering is a comparatively easy matter, a double row of props with 6-inch lids

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

and 6-inch sill-pieces being suitable, the 6-inch sill-piece being adopted to prevent the prop from being forced into the soft floor. If the floor is hard the props should have an 8-inch taper, so as to give a little when the weight comes on. Temporary cogs should be built every 8 feet as a precaution against the roof breaking over the props, the same being built upon a foot of fine dirt to facilitate their removal. Permanent cogs should be built on each side of the roadway every 6 feet apart, and a pack wall should be built between them and continued on each side of the roadway, the same being at least 8 feet in width, and kept as near to the face as possible, cross walls being built up at intervals.

Assuming the roof to be weak, and the long wall method of working is in vogue, then sprags should be inserted every 4 to 6 feet, and the roof over the tram road should be supported by flats, 5 feet 6 inches in length, 10 inches broad, and 3 to 4 inches in thickness; the same being surmounted upon two iron or wooden arms, thus allowing ample room for the passage of the trams along the face. Props with lids should be set in addition to the flats as soon as there is enough room for them, and withdrawn when sufficient room to erect flats is obtained, to allow the road to be relaid and the trams to pass along the face as before. To prevent the weight being thrown on the face all temporary cogs, which should be set every 8 feet, and all back timber, should be withdrawn.

For the above seam, if the system of working is long wall, the following rules should prove effective:—

Maximum distance from the nearest roof support to coal face, 3 feet.

Maximum distance apart of roof supports to coal face, 2 feet 6 inches.

Maximum distance apart of rows of flats to coal face, 3 feet 6 inches.

Maximum distance for sprags to be set to coal face, 4 feet.

Maximum distance apart of packs to coal face, 10 feet.

Minimum width of packs to coal face, 8 feet.

All timber and temporary cogs to be immediately withdrawn when the face road has been moved forward.

The method of timbering will be easily understood by reference to sketch.

Jos. C. Rodman, 58, Canning Street, Cwm, R.S.O., Mon.

D. McBurnie, D. T. Evans, J. Jones, Junr., S. F. Middup, L. J. Thomas, T. Gaskell, S. McLuard, C. Simpson, T. E. Edwards, F. Mitchard, W. Williams, S. Bateman, J. H. Cumberbatch, J. Brooks, J. Luty, A. Champkins (*12 marks each*).

John Taylor, J. Morris, Joseph Taylor (*8 marks each*).

T. E. Edwards, G. Davies (*4 marks each*).

Gases in Mines.

Q. 2.—*What do you know about the law of the diffusion of gases, and its effect on their behaviour in mines?*

A.—By the diffusion of gases it is meant that the various gases diffuse, or in other words they get thoroughly mixed or scattered, they flow in all directions and get thoroughly intermingled with each other.

Gases differ in their respective weights or specific gravity. As their respective weights or density have a bearing upon the rate of diffusion (that is to say, a light gas will diffuse much quicker than a heavier one) I append the following table:—

	Symbol.	*Specific Gravity.*	*Atomic or Molecular Weight.*
Carbon monoxide ..	CO	·969	28
Carbon dioxide	CO_2	1·529	44
Sulphuretted hydrogen ..	H_2S	1·191	34
Carburetted hydrogen ..	CH_4	·557	16

Taking atmospheric air as representing unity, or 1·00, we naturally find the foregoing mentioned gases at a higher or lower level according to their respective specific gravities, when we compare them with air. Therefore it follows that CH_4 (which is more commonly known as fire-damp) always ascends to the roof, or cavities, in the mine; on the other hand, CO_2 or carbon dioxide rests on the floor of the mine.

This would be the natural state of things, because CH_4, being only about half the weight of air, it would float above the air flowing through the mine; whereas CO_2, being approximately one and a half times the weight of the air, would sink to the floor of the mine. Other gases would also find their positions according to their respective densities.

If the above statement is correct then we would expect to find the face of the earth covered with a stratum of CO_2, where it would be impossible for us to live. Also every mine must naturally be filled with CO_2, thus making it impossible to work them. Seeing that we are able to live on the face of the earth and also work in the mines, there must be some natural forces at work to counteract the natural tendencies of the various gases. The best known force is the ventilation of the mine, and another but not so well known force is the *diffusion of gases.*

The law of diffusion is a natural one, and it is always at work. It does not matter what may be the weight of a gas, it will diffuse or intermingle with any other gas. That is to say, a heavy gas such as CO_2 will ascend and mix with a lighter gas such as CH_4 and *vice versa.*

If for instance we fill a long glass tube with CO_2, and then place an inverted glass tube with atmospheric air in it upon the tube of CO_2, and let them remain in that position for a length of time, it will be found that the CO_2 has ascended into the uppermost tube, and diffused or mixed with the air in that tube; also the air in the upper tube will descend and diffuse or mix with the CO_2. To prove this pour a small quantity of lime water into each tube, and it will be found that the CO_2 in each tube will turn the lime water *milky.*

This is a sure way of detecting the presence of CO_2 in any place. As stated a heavy gas will diffuse or mix with a lighter one and *vice versa*, yet it must not be supposed that they will diffuse at the same rate. A heavy gas will take a longer time to diffuse than a light one. For instance 100 cubic feet of CO_2 would take a longer time to diffuse than a similar quantity of CH_4. Graham, from the results of his experiments, deduced the law that gases diffuse with one another *inversely as the square root of their densities.*

To keep a mine in a healthy state, and safe for working, also to assist in the diffusion of gases, strong currents of atmospheric air are introduced to ensure the workings of the mine being kept in a salubrious state. Natural diffusion in itself would not keep the workings fit for working, therefore induced currents of air are introduced throughout the mine to remove the gases and assist the diffusion.

It is plain to be seen that, although gases are always in motion, by introducing a current of air we increase the rate of diffusion according to the velocity of the air-current.

Although there is a large quantity of CO_2 throughout the mine, which would owing to its density settle upon the floor of the mine, yet owing to the effects of diffusion, greatly assisted by the ventilation of the mine, it is not allowed to settle there except in the lower portions of the mines, sumps, or old working to the dip where there is no ventilation. The same would apply to CH_4, except that it would, owing to its being lighter than air, ascend to the highest parts of the mine, such as the roof, cavities in the roof, also old workings to the rise.

The reason that we find CH_4 or fire-damp in an explosive mixture in cavities in the roof is from the fact that the rate of diffusion does not keep pace with the rate of issue of the gas from above. By conducting a current of air into the cavity the rate of diffusion is greatly increased, thereby diluting the fire-damp and making it non-explosive.

A practical example of how the diffusion of gas takes place is to turn on the gas in a room and in a short space of time it will be detected from its smell in every part of the room, from the roof to the floor, also it will escape if there is any outlet to the outside atmosphere where it again is detected by its smell. Its natural tendency would be to ascend to the top of the room, but from the law of diffusion it has spread itself throughout the whole room.

We would find upon an analysis of the return air of a mine a mixture of atmospheric air, carburetted hydrogen, carbon dioxide, sulphuretted hydrogen, carbon monoxide, &c., in certain percentages. These gases upon leaving the mine would be diffused or thoroughly mixed with each other, in proportion to the amount given off in the mine and according to the rate of diffusion.

James Harris, 3, Harcourt Terrace, Penrhiwceiber, South Wales.

J. C. Rodman, S. F. Middup, L. J. Thomas, A. E. Helps, T. Gaskell, C. Simpson, W. Hawthorne, T. E. Edwards, F. Mitchard, J. Redfearn, A. Wright, G. A. Hyde (*12 marks each*).

W. Caswell James, J. Brooks, J. Morris, G. Davies, W. Williams, R. Fisher, J. Jones, Junr., D. McBurnie, W. Hodgson, Junr. (*8 marks each*).

T. D. Edwards (*4 marks*).

Shot-Firing.

Q. 3.—*In electric blasting what are the chief causes of miss-shots?*

A.—The causes of miss-shots where the firing is done electrically may be stated as: (1) Faulty charging and tamping; (2) faulty coupling up of wires, cable, &c.; (3) defective cable; (4) defective exploder.

1.—When charging the shot-hole the detonator may not be properly fixed into the last of the cartridges, therefore when the tamping is being applied the detonator may become loose. Again the detonator may leave the cartridge when the latter is being pressed to the back of the hole. Some shot-firers fix the detonator into the first cartridge when charging, then bend the wires back over and press the cartridge home with the detonator at its in end. If not properly fixed the detonator may become loose as in the first case; again the bending back of the detonator wires may cause one of them or both to snap, and the passage for the current would be broken. When tamping a piece of sharp stone may be present in the tamping material unseen by the shot-firer, and this when being pressed into the shot-hole may cut the detonator wire covering and cause a short circuit of the current.

2.—Should the connections between cable wires and detonator wires and cable and exploder terminals be badly made then it is possible for the current to be broken, and be the direct cause of a miss-shot. To avoid a miss-shot from this occurrence the wire ends should be made perfectly clean, and properly twisted around each other "lead" to "lead" and "return" to "return." The shot-firer should see that the "lead" and "return" wires do not come in contact. On no consideration should the bare wire ends be allowed to come into contact with any conducting substance, such as the stone, strata, &c.

3.—A defective cable may be the cause of a missed-shot. The cable in places may have become worn, thus exposing the wires. Thus when the cable is laid along the floor ready for the firing operation one of the wires may be in contact with the strata or the iron rails, or other conducting material. Again the wires may have become broken through excessive use of the cable, or by the blowing of large stones from the shot thereon. All such defects will cause a miss-fire. To save the end of the cable in the shot's vicinity it should be passed over a bar supporting the roof if possible, and it will thus be blown clear when the shot explodes and saved from undue damage.

4.—Defective exploders will cause miss-shots, because sufficient current will not be generated to explode them. Exploders should be kept in the best condition, dampness being guarded against.

The above are the chief causes of miss-shots when firing by the electric method. Of course, there are others, such as firing too many shots together, the exploder current not being strong enough for the purpose. Sometimes when a missed-shot occurs the cause is put down as a bad detonator. With low tension detonators such an occurrence as a defective one should not be considered, because all are tested before being used. With reasonable care in the charging and tamping of a shot-hole, in the coupling up, &c., there should be no case of a missed-shot should the firing means be in good order.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

J. C. Rodman, T. Garbett, B. J. Noot, L. J. Thomas, A. Whittingham, J. E. Tredgold, S. Beardsley, J. H. Moore, T. Gaskell, W. Hawthorne, J. Luty, T. E. Edwards, F. Mitchard, W. Williams, Joseph Taylor, R. Brettell, H. V. Smith, E. Jones (*12 marks each*).

A. Wright, W. C. James, John Taylor, J. Brooks, J. Morris, G. Davies, S. F. Middup, D. McBurnie, R. Fisher, T. D. Edwards (*8 marks each*).

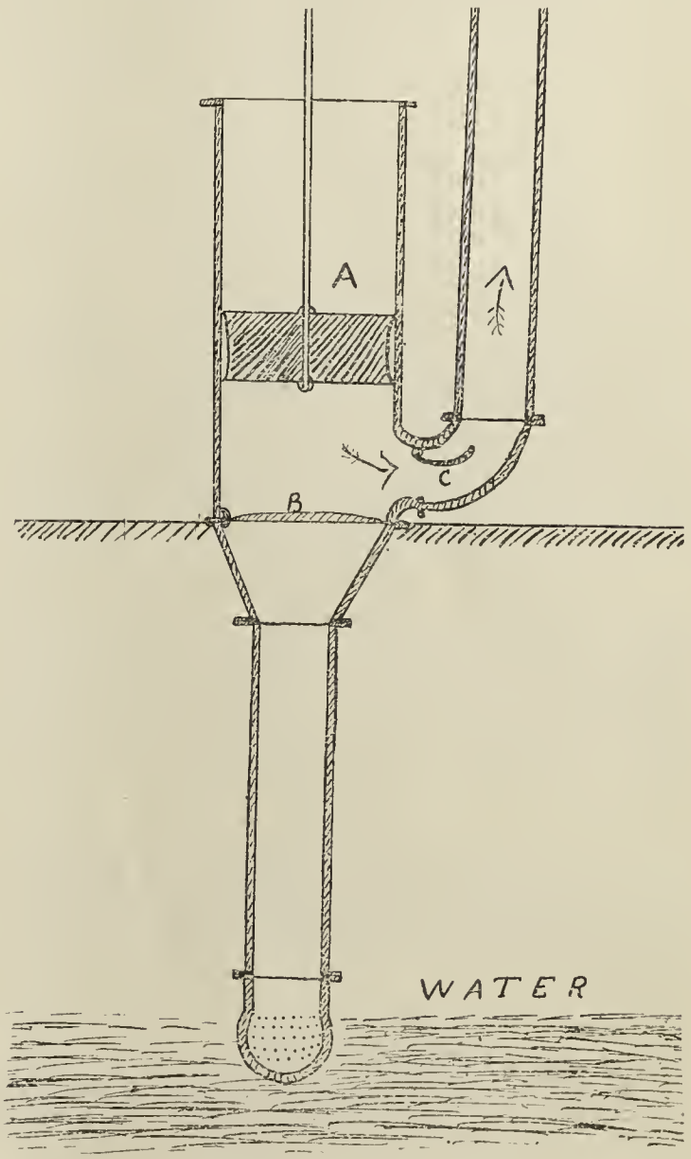
S. McLuard (*4 marks*).

Pumps.

Q. 4.—*Describe the working action of a forcing pump.*

A.—A force pump may be termed an atmospheric pump, and will force and deliver water any height dependent upon power and strength. The suction end of the pump is therefore governed by atmospheric pressure, which forces the water in the working barrel, the delivery end being governed by the power and strength of the engine, which forces the water into the rising main.

As the pressure of the atmosphere is taken advantage of for forcing water into the working barrel, let it be understood that the vertical height is limited to a theoretical height of about 34 feet. This we can prove by taking 30 inches of mercury



Illustrating Question 4.—A, piston rod; B, suction valve; C, delivery valve.

in the barometer tube, multiplying it by 13·5, and dividing it by 12, will equal 33·7, or say 34 feet. Again the pressure of the atmosphere is taken as 14·7lb. per square inch, and as the weight of a cubic inch of water weighs ·036lb., the height of a column of water which will balance the pressure of the atmosphere is 14·7 ÷ ·036 = 408 inches or 34 feet.

It will be seen at once that if we had a column of pipes 34 feet high, with the lower end immersed in water, and a perfect vacuum obtained in the pipes, the water should be forced up the pipe so as to completely fill it. In connection with force pumps it is impossible to obtain a perfect vacuum in the suction end or working barrel, with the result that the maximum working limit is about 28 feet, and the best results are obtained when the vertical height of the suction end does not exceed 20 feet.

The force pump should be so constructed that the working barrel is made air-tight, so that upon the upward stroke of the piston a vacuum is formed in the barrel. The vacuum thus formed, nature abhors it, and thus water is forced into this chamber through the suction valve by the atmospheric pressure.

The working action of the force pump is very simple. As already stated, the first process is that of the water being forced into the working barrel from the sump or water-hole by atmospheric pressure. This is brought about in the following manner :—

When the piston rises in the working barrel, or suction chamber, as it is sometimes called, a partial vacuum is formed ; then owing to the pressure of the atmosphere acting upon the surface of the water into which the suction pipes are immersed, the water is forced through the nozzle into the working barrel, thus filling it. When the piston makes its downward stroke the bottom clack is closed, and the water is forced through the top clack into the rising main or delivery pipes, and thus delivered.

The working action of the force pump may be understood by reference to sketch, as it acts in an intermittent manner. When the pump is working every upstroke of the piston that is made the barrel is filled with water from the water-hole or sump ; upon the downward stroke of the piston the barrel is emptied, the water being forced through the delivery pipes. There are double-acting force pumps, which means that they have two working barrels, and pump water both with the forward and backward stroke. With double-acting force pumps the water flows through the delivery pipes in a regular manner and not in an intermittent manner, as with the single-acting force pump, yet the mode of action is the same.

In conclusion the working action of the force pump may be stated as follows :—The water is forced to the pump by atmospheric pressure. It is then forced from the pump by the pressure or power of the engine.

Assisted by PARKER'S *Mining Science.*

THOS. GASKELL, 138, Downall Green Road, Bryn.

[NOTE.—We selected the preceding answer chiefly because together with the sketch it formed about the simplest explanation of the principle upon which the forcing pump acts. Better sketches, perhaps, certainly more elaborate, were received, but they were not so easy to understand by anyone not conversant with pumps. Students should notice the way in which the two clacks or valves open and shut.—C.C.M.]

J. C. Rodman, D. McBurnie, J. W. Brough, S. F. Middup' B. J. Noot, L. J. Thomas, J. E. Tredgold, J. Cheetham, C. Simpson, W. Hawthorne, Joseph Taylor, James Morris, F. Mitchard, S. Bateman, R. Brettell, J. Luty, W. C. James, J. Redfearn, G. A. Hyde, R. Benson (*12 marks each*).

J. Brooks, John Taylor, W. Williams, T. D. Edwards (*8 marks each*).

Pumps and Pumping.

Q. 5.—*Three parallel places being driven to the dip are much troubled with water. The dip is 1 in 9. State how you would keep the faces clear of water.*

(No selected answer).

[NOTE.—We were not at all satisfied with the answers sent in this question. Some suggested pumps to work for an hour at a time, and then stop for another hour ; while others recommended pumps to work twelve hours, and then rest twelve hours. It is evident that, to comply with the terms of the question, our pumps must work continuously, or we shall not "Keep the faces clear of water." Of course we can keep two of the dips clear from water easily enough by keeping the third in advance of them, but the last can only be kept clear by continuous pumping, or at least filling into tanks. One competitor would persist in calling these roads "levels." Altogether, we did not receive any answer to this question which merited recognition.—C.C.M.]

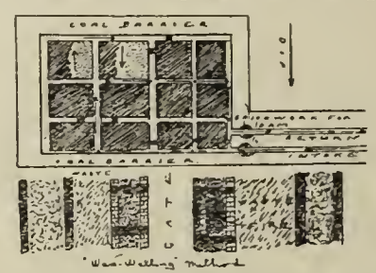
J. Harrison, A. Stephens, A. Nelson (*12 marks each*).
T. G. Hay, E. Ambrose, J. Grundy, A. Bulter (*8 marks each*).

Methods of Working.

Q. 6.—*In a seam liable to spontaneous combustion it has been decided to remove the pillars. The seam is 9 feet thick. Describe fully the points to which you would direct special attention.*

A.—In a coal seam nine feet thick it is hardly possible to employ long wall in the first working ; the result is that coal pillars must be formed in order to protect the roof, and the conditions will soon become very liable to initiate fires, more so if the thill and roof are hard and compact, in which case these two forces often grind up the pillars—especially if small—into a powdery mass.

The best method I know of is to form panels about 100 yards in length, and 150 yards broad. When it is intended to extract the pillars, they are commenced upon from the rise side to the dip. (See *Figure 1*). After driving the narrow roads which cut up the main panel into a number of smaller ones, the rise pillars are gradually robbed. The extraction should be accomplished, especially in the case of the uppermost ones, as rapidly as possible, and to obtain this end two shifts should be employed if possible. When the pillars are thus robbed the gases, if any are present, escape from the coal to the wastes above. As each row (see sketch for meaning) of pillars is extracted stoppings are fixed to prevent the circulation of air through the new goaf. The next lower level being the return, the goaf is swept by a very feeble current only. In this system of pillar working the working edge of the goaf is always in touch with the ventilating current, whilst the pillars are being removed. Its



Illustrating Question 6.

chief merits are : The pillars are quickly opened out, extracted, and finished, and should a fire occur during their extraction the two entrances can be easily dammed off. The objections are : The great amount of narrow work is expensive, and also productive in small. There is also a great loss of coal when ribs have to be left to form fire-barriers, especially in seams of high inclination. It is the practice in some mines to adopt the "wax-walling" method. The gates are supported on brattice wood on the sides, behind which the "wax-wall" is erected, consisting of lumps of well-tempered clay, 1 foot thick. A fire rarely occurs in a perfectly sealed off goaf, and in case one did occur it would soon be extinguished. (See sketches). Another point worthy of mention is that a thick coal seam cannot employ "wax-walling," unless the system of working is modified.

The points I would direct special attention to are :—

(*a*) If any heating breaks out in any pillar the general method of combatting the same may thus be stated : If it is discovered at some point inside the pillar, *i.e.*, in the solid coal, I should trace the fractures, and load out any coal in a heated state. This drivage would be kept open and ventilated, and hence have a cooling influence upon the surroundings ; if I saw that keeping open this road would occasion possible risk of restarting heating, well pack with sand, ashes, &c., and dam off.

(*b*) If the circulation of air in any narrow driving had bad influences upon the coal, I should have the same well arched for a considerable length, and maintained air-tight by plastering or elaying the brickwork.

(*c*) In case the heating occurs in a goaf and is accessible, the best plan would be to load and remove the heated material, and tightly fill the excavation with a non-combustible substance, after the same has cooled.

(*d*) In case the fire has actually commenced and such material cannot be removed, or a fire is suspected but cannot be reached, damming off of such an area, with a view of preventing the access of air, is the last resource.

When a fire takes place in the solid it usually originates in

the fissures or cracks formed by the pressure, consequently any attempts to prevent or alleviate pressure tends to prevent fire. The places where fires often occur in the solid are: (1) At or in close proximity to the edge of the pillar. (2) At stoppings built between main intakes and returns. (3) In narrow ribs of coal. (4) In the pillar between two roads that are close together. In practically all of these places crushing has taken place to a more or less extent, and a certain amount of air has been allowed to enter and create oxidation, which creates heat. The heat in such cases accumulates because the air is not sufficient to carry it away. All the coal should be extracted, even though it be of an inferior quality. Also the withdrawal of timber from the goaf is recommended, because wood is much more easily ignited than coal.

Assisted by notes by A. H. BONNER, and notes in No. 21, Volume 22 of this Journal.

A. NELSON, Maes-y-Dyffryn, Glyn Neath.

E. Ambrose, J. Grundy, A. Stephens (*12 marks each*).

Mine Gases.

Q. 7.—*Explain why, although gas may burn explosively inside the gauze of a safety-lamp, it will not ignite the same mixture outside.*

A.—My explanation is as follows: In the first place we are definitely given to understand that the principal and safety part of any safety-lamp is the iron wire gauze cylinder, which consists of very fine iron wire about $\frac{1}{50}$ of an inch thick, having 28 lines to the inch, or 784 meshes or apertures to the square inch. Then the apertures of the gauze being so small, and iron being such a good conductor of heat, neither the flame in the gauze of the lamp nor the gases that may burn explosively inside the same can pass through it with sufficient heat to ignite the same mixture outside the same gauze (providing the gauze is in no manner defective), simply because as soon as the flame is brought into contact with the gauze the iron wires which form the apertures reduce it below the temperature of white heat, thus preventing the gaseous mixture outside from being ignited. To state it more concisely flame consists of gases at a white heat, hence the gauze being of a lower temperature than that of flame, the actual flame will not pass through the meshes of the gauze.

We have several instances recorded of fire-damp and air igniting inside the gauze of a safety-lamp, and causing the gauze to become red hot; but still the outside mixture has not ignited, due entirely to the afore-mentioned reasons. It seems I dare say a hard statement for some readers to comprehend although so simple, that a mass of flame can be separated from a quantity of one of the highest explosives possible (CH_4 and air) by so simple a construction as a thin network of wire $\frac{1}{50}$ of an inch thick, with 784 apertures to the square inch, and not ignite. It is easy now to understand that any safety-lamp depends entirely for its safety upon the gauze, and the employment of the same in a lamp is to conduct the heat away from the flame so rapidly that the temperature does not rise to the point required to ignite any explosive mixture that may be prevailing outside. From this data we may define a safety-lamp to be a lamp whose construction is of such a character as to isolate the flame or light from the surrounding atmosphere, in which it may be placed or carried for the time it is in use affording the facility of detecting the presence of fire-damp (CH_4) in a ready and safe manner—of course, assuming such to be in perfect condition.

Jas. Grundy, 550, Wigan Road, Bryn.

[NOTE.—It cannot be too clearly understood that the gauze of a safety-lamp is only of temporary value in preventing the ignition of fire-damp on the outside. Granted that the percentage of gas in the air is just sufficient to keep burning inside the gauze it is only a question of time before the gauze will become so hot as to lose its power of absorbing the heat of the flame, which will then pass through the gauze and ignite the gas on the outside. Of course in the case of many of our best safety-lamps if the gas fires inside them the flame is extinguished, but that is not at all due to the gauze, but rather to the arrangement of shield or bonnet which prevents the produets of combustion from passing quickly enough out of the lamp, with the result that the flame is extinguished owing to a lack of sufficient uncombined oxygen to support combustion.—C.C.M.]

E. Ambrose, A. Nelson (*12 marks each*).

A. J. Johnston, J. Harrison, A. Stephens (*8 marks each*).

Compressed Air.

Q. 8.—*Recognising the losses arising in the use of compressed air, state generally what arrangements you would adopt with a view to obtaining the best results.*

A.—The loss of power commences during the compressing stage and continues all along until the point of application. Considerable heat is developed during compression, and nono of this is converted into useful mechanieal purposes, and is therefore a great waste. Next come the losses during circulation, which may be divided into three classes: (1) Leakage; (2) condensation; (3) friction.

To mitigate the loss due to the reduction in temperature prior to being utilised at the face, some efficient means of cooling is most essential, or in any case, this combined with some method of reheating at the motor is necessary so as to economically use the air. Water jacketing is the usual expedient, although not a very efficient one. Air is not a good conductor of heat, and consequently it is only the outer layer of it that is directly influenced by the cooling surface. Moreover as it is only towards the *end* of the stroke that the temperature becomes high it will be seen that a very small area is at this moment exposed to the cooling influence, unless also the ends of the cylinder are water-jacketed, in which case the inlet air is usually admitted by means of valves fixed in the piston. When this form of water-jacketing is employed a good plan, if possible, is to connect the inlet port to the delivery end of a pump or a siphon if available. Another less frequent form of cooling consists of a spray of water injected at each stroke into the cylinder. A piston of water has in some cases been tried, but it has not met with any great approval. The best arrangement, and one which adequately lends itself to cooling, is that of compounding, whereby the compression of the air is divided into a series of two, three, or four stages, as the case may be. By means of this arrangement the evil of extreme variations of temperature is avoided, and the air, by a suitable arrangement of intercoolers (see sketches) placed between the stages, can be maintained within reasonable limits of temperature. Before the arrangement is complete an after-cooler is often used, which serves the purpose of draining off part of the moisture prior to its admission to the pipes. *Figure 1* illustrates a section of the Sergeant vertical intercooler. Its action is similar to a surface condenser. The warm compressed air enters at the top, and passes down around a set of vertical pipes, though which cold air circulates continuously; it then rises up and leaves the sides. *Figures 2* and *3* show the Ingersoll-Sergeant horizontal type, which merely consists of a nest of tubes carrying water, so that the air coming in contact with them is split up and meets with an extensive cooling surface. When the compressed air is conducted through a series of stages (if compounding is used), the final temperature of expansion should correspond to the initial temperature of compression. This is hardly possible in practice; but in some instances an approximation thereto might be made, and in proportion as this is the case, so will the efficiency be. When the expansive property of the air is utilised to the fullest degree, as in the case of pumping, &c., advantage should be taken of the possibility of reheating between the stages, *i.e.*, the reverse of the cooling proeess during compression.

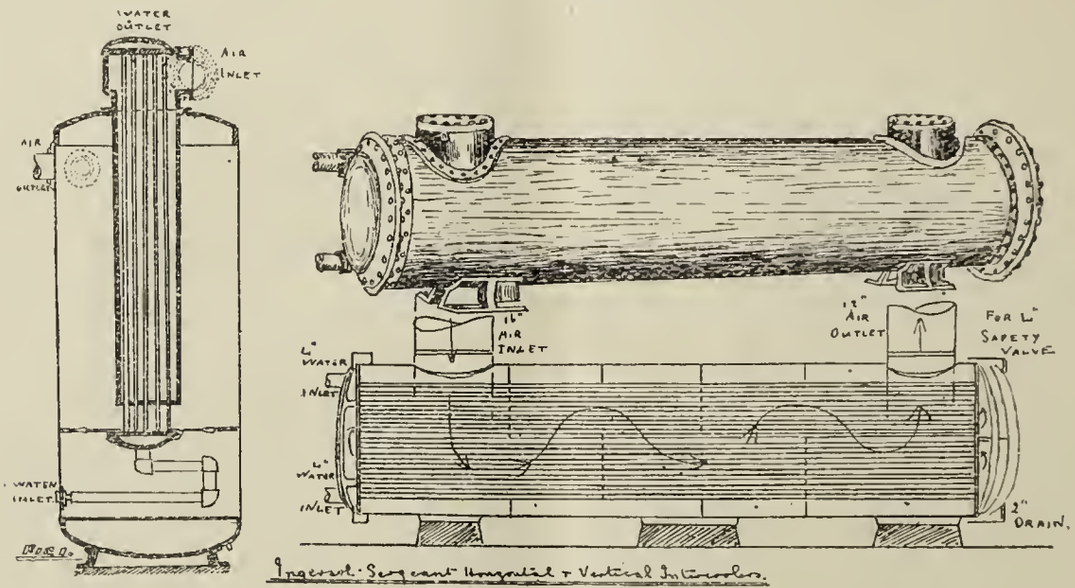
Condensation may prove a great loss, unless a proper system of air receivers, provided with taps for running off such water is employed. If the air is transmitted over long distances the conducting pipes need the closest care and attention in order to procure a fair degree of efficiency. They should be in proportion to the work they have to do. There are losses due to bends, and increase of pressure due to depth of shaft. Seeing that the resistance varies as the square of the velocity, it is evident that the latter should be kept as low as possible, for by halving the velocity the resistance is one-fourth. Consequently the pipes should be of ample area, and where joints are employed at any place they should be such as not to restrict the air passage. The velocity of flow should never exceed 50 feet per second. Sudden reductions of area, or change of

direction, are sources of loss, whilst knees and bends, as they add to the friction, should be avoided wherever possible. Care should be taken as to the fixing up of junctions, &c., to avoid leakage; for air, unlike steam (when escaping) is invisible, and does not create the same inconvenience in the roadways, and therefore any leakage is more likely to be passed unobserved.

We have already seen that when air is compressed the heat produced is soon dissipated, and the energy corresponding to it lost. If this heat could be restored at the motor, the energy could be regained. It is possible to do this in some situations by passing the air pipes through, say, a fire or over a lamp just previous to its point of usage. In mines this arrangement is rarely possible.

In dealing with air a much smaller quantity of heat is necessary than if we were dealing with water. Steam, or even hot water, conveyed in a small 1-inch pipe can be used as a reheating agent very efficiently, so too might electricity, as also at the exhaust ports to prevent freezing.

Loss due to flexible connections can be easily avoided by using good class of pipes and as short as possible. The rubber should not be allowed to rest in water, as this further tends to develop condensation. The hose should not be dragged along the floor, but should be carefully conducted.



Illustrating Question 8.

In the injection compressors water is constantly forced into the cylinder in order to extract heat from the air contained, and besides this it has the effect of partly filling the clearance spaces or pockets, and consequently contributes to the more efficient working of the compressor. The "Dubois and Francois" is a good example of an injection compressor.

Indebted for assistance to BOULTON'S *Mining* and to *Elements of Mining and Quarrying* by FOSTER and C. H. COX for *Sketch 1*.

A. NELSON, Maes-y-Dyffryn, Glyn Neath.

[NOTE.—The chief loss of power in the use of compressed air lies in the reduction of temperature in the air from leaving the compressor to reaching the engines. The cooler the air can leave the compressor the less will be the loss of heat in passing through the pipes. If the air could leave the compressor at the same temperature as the surrounding pipes and external atmosphere there would then be no loss of temperature and no loss of power due to that cause. It must of course be understood that our efforts to cool the air must be performed before it leaves the compressor, and not afterwards. After it has left, our aim must be to retain the heat in the air as much as possible in order to retain the pressure.—C.C.M.]

A. Stephens, J. Grundy, E. Ambrose (*12 marks each*).

FIRST CLASS.

Surveying.

Q. 9.—*The workings of a colliery operated by shafts extend over an area of 500 acres. A new plan is found to be necessary, requiring a re-survey of the surface boundaries, and underground workings. Describe how you would carry out this work.*

A.—Wherever the character of the ground and other circumstances permit, the framework of a surface survey of a colliery is best made by the method of triangulation. By the triangulation method the whole surface area is covered with a network of imaginary triangles, of which the angles must be measured.

Reconnaissance.—Before laying out a triangulation, it is necessary to make a preliminary observation, so as to become acquainted with the chief features of the ground to be surveyed, boundaries, and position of shafts. The surveyor should take a walk round the royalty, and as far as is practicable he should take a comprehensive view of the same, and make a rough sketch. This is for the purpose of (*a*) finding the site for the main line; (*b*) the points in the boundaries to which to chain the side lines of the triangles from the base; (*c*) the points on the base line and boundaries respectively through which to range out tie lines and also subsidiary lines to embrace the main features of the taking which are to be delineated upon the plan.

The base line should be ideally at the middle of the royalty, and as long as is conveniently possible, and must essentially lie evenly between two points which have no serious obstruction between them.

The triangles should be arranged in such a manner that the base line or shorter lengths of it, as desired, will serve as a base, and the other two sides pass as near to the boundary as is possible. This is necessary to ensure the accuracy of the survey, for if the triangles are arranged in such a way that their sides are a long distance from the boundaries it follows that long offsets (which reduce the accuracy of the work) will have to be taken. Care should be taken to see that such an effort does not result in the triangulation becoming of an inferior order of accuracy, owing to the number of triangles having to be increased and their shapes often being necessarily ill-conditioned.

The chief trigonometrical stations should be selected from the standpoint of making large, good-shaped main triangles, whose sides shall serve as bases for fixing additional points to which the subordinate or detail surveys are connected. In sketch the triangles *ADE* and *CBF* are the main triangles, and these have the base line as their base. When I had determined the base I should place a pole at each extremity. Afterwards I should (1) range out the main triangles; (2) fix tie lines; (3) choose the direction of the "filling up" lines of the main triangles; (4) range out the subsidiary triangles; (5) determine the direction of the picking-up lines of the subsidiary triangles.

In explanation of the sketch, the small circles with arrow head denote number and direction of chain line, shaded lines represent boundary hedges, *AB* position of shafts, and dotted lines show chain lines.

The tie lines should be arranged from the sides of the triangle

to the respective base of such, which is a base line or part of it, and these lines, together with the subsidiary lines which are set out to "pick up" the objects to be delineated upon the plan, serve as connecting lines for the main triangles of the survey. The theodolite is generally used for angular work, and a chain or steel tape for measuring the base line, &c. The results obtained are entered into the field book by the surveyor. It may be taken as a rule that the measurements of the lines in a triangulation survey are not accepted as correct unless they are checked in some way. In the main triangles the tie line or the containing angles verify the accuracy of the work. The lines for filling in the triangles are run between stations already fixed on preceding lines, and the scaled lengths between the stations on the plan must agree with the measured lengths of the lines before the work is deemed satisfactory.

Connecting Surface and Underground Surveys.—The positions of stations established near shafts, &c., for the purpose of connecting the underground and surface surveys, must be determined with great precision.

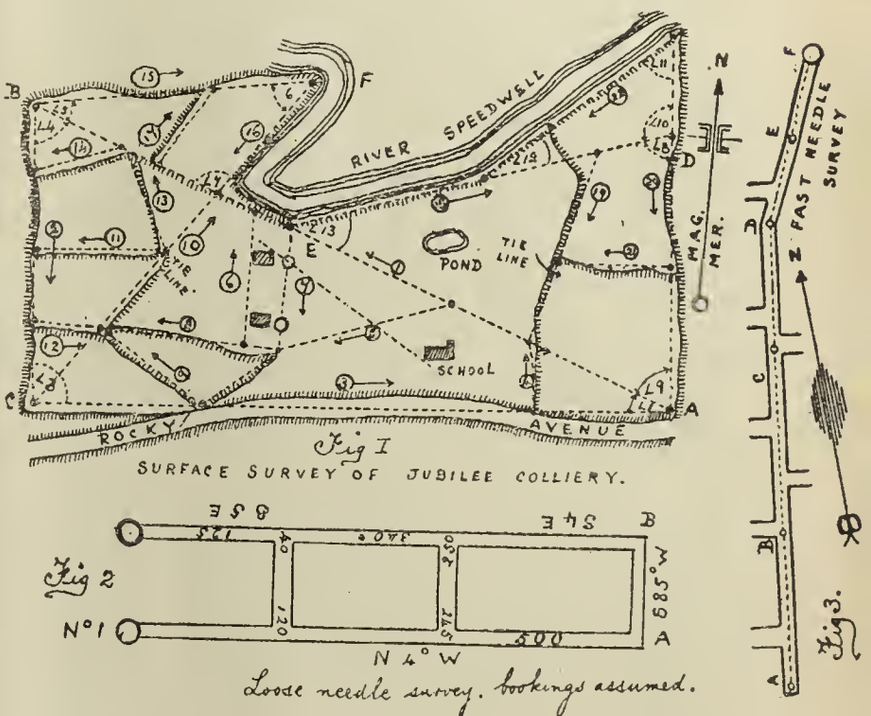
The simplest and most reliable base line is the magnetic meridian, and is the one which I should adopt. The connection between the underground and surface, adopted by Bennett H. Brough, is made as follows:—The connection of the underground and surface surveys is made by means of two plumb lines, one suspended in each shaft. The points of suspension are joined to the surface-triangulation by means of careful measurements. In this way the length and bearing of the line joining the two plumb lines may be calculated by means of rectangular co-ordinates. A traverse is then made underground from one plumb line to the other, and from the data thus obtained the length and bearing of the line joining the two plumb lines are again calculated by means of co-ordinates.

In the magnetic meridian method described by T. A. O'Donahue when the underground survey has been made and the magnetic bearing of one or more of the traverses being known, a magnetic bearing is taken between two well-defined objects on the surface which are represented on the surface plan. To ensure accuracy it is desirable that the objects should be some considerable distance apart. Having obtained the magnetic bearing of the line, the direction of the magnetic meridian is then plotted on the surface plan. The angles which the underground traverses make with the magnetic meridian being recorded by the underground survey and one point, that is, the centre of the shaft being common to both the surface and underground surveys, the underground survey may be laid down on the surface plan.

Underground Surveys.—To make a survey underground it is necessary to have some fixed station—the position of which is shown on the plan—to locate the survey. Such station may in the first place be the centre of the shaft, but as the workings extend it would be impracticable to commence the survey each time at the shaft, and the usual custom is to leave stations on each survey to which succeeding surveys may be connected. If a survey be connected to one station only there may be an error in the work which is not apparent. When possible therefore a survey is commenced from one station and terminated at another, so that when the traverse is plotted on the plan if it does not "tie in" to the last station it is obvious that some part of the work is wrong, always providing that the positions of the stations are accurately shown. If a new plan is required the whole of the workings should be re-surveyed, the work being done in sections, "tieing back" to a station (or stations) which is known and conveniently placed. In the circumstances mentioned in the question, I should survey each district in turn, commencing from the downcast and finishing at the upcast. A description of the underground survey can only briefly be dealt with here.

Loose Needle Surveying.—Commencing from the downcast shaft No. 1 the surveyor would proceed along the roadway, occasionally looking back to see if he can still see the light, and if so would set up at *A*. Levelling the dial, and unclamping the needle, he will turn the *S* end of the dial towards the light and then move the sights until the vertical hair cuts the flame of the lamp. He now reads the bearing, which we will assume to be N4°W. The chainmen then measure the distance with the chain, reading off the cross-roads as they pass. These measurements along with the bearing are booked by the surveyor, who makes a rough sketch as the survey proceeds. Turning the sights round until the *N* end points in the direction the survey is proceeding, he takes an observation to *B*, looking through the *S* vane. After booking the bearing he moves forward to the station *B*, the chainmen following on, and measuring the distance, and can if he prefers take a back sight to *A* and check the bearing. Moving forward to *C* he can take a bearing to *B*, and another to the centre of the shaft. These bearings with the measurements complete the survey. The plotting will also check the accuracy of the survey.

Fast Needle or Racking Method of Surveying.—There are various methods of racking in use. We will assume that the point *A* is the starting point, and the needle is allowed to swing freely until it settles in the magnetic meridian. The dial is gradually turned until the N and S graduations exactly coincide with the north and south ends of the needle, and the dial is clamped in this position on the legs by means of the screw. A base line is thus obtained from which the remainder of the survey may be worked. The peg which holds the two pates of the dial together is withdrawn, and the sights are adjusted to the light held at *B*, *Figure 3* (the north end of the dial being towards the light) by turning the tangent screw, and are clamped in this position by the vernier clamp, which prevents any movement between the two plates. The position of the vernier is then read and booked, and the vernier retained in this position;



Illustrating Question 9.

the dial is set up at *B*, and is adjusted to the light at *A*, the S end of the dial being towards the light. The dial is clamped in this position on the legs, and the two plates of the dial are unclamped by releasing the vernier screw. The sights are then adjusted to *C*, again clamped by the vernier screw, and the vernier reading taken and booked. The dial is next removed to *C*, the vernier being retained in the position fixed at the last sight. The back sight is taken to *B*, the dial clamped on the legs and the vernier clamp released. A forward sight is taken to *D*, the vernier clamped in this new position, and the reading taken and entered in the book. The instrument is taken and fixed up at *D*, and backward and forward sights are taken as before. In this manner any number of bearings may be taken; and it is advisable at the termination of the survey, or at any other suitable position, to allow the needle to settle, and thus obtain a check upon the bearings, taking care to see that the needle is not influenced by some hidden attraction. If the check bearing has been correctly made at any place free from attraction, the needle should read exactly the same on the upper graduated plate as the vernier reads on the lower plate.

All bearings and measurements should be carefully booked,

together with direction and position and extent of all faults, dip of mine, position of the workings, &c., so as to facilitate plotting and the correct making of the plan as required by the C.M.R.A.

The above are the chief methods I should pursue for the surface and underground surveys. Before plotting I should collect all the requisite data, and plot to any convenient scale not less than 25 inches to the mile, a most convenient scale being 30 yards to an inch.

The writer must apologise for many shortcomings in the above answer, but hopes to be excused because this is a question upon which volumes may be written.

Indebted to various authorities, chiefly a back number of *The Science and Art of Mining*, and also *Colliery Surveying* for part of the above answer.

WALTER HEYS, 1, Walter Street, Huncoat, Accrington.

[NOTE.—Having recently completed the survey of a colliery taking of over 6,000 acres, and of underground main haulage roads of a total length of over 50 miles, perhaps our own method of procedure may be worth mentioning. The property being situated in extremely mountainous country, it was very difficult to obtain a suitable base line. One however was obtainable about threequarters of a mile in length, the ends of which were in sight of each other, and also of two other prominent points in two mountains about two and a half miles away. By taking the angles at each of the points it was possible by the aid of the measured base line to calculate the distance between the two furthest points. This line was then adopted as the main base line for the survey. Triangles were laid out on each side of this base line and further triangles off the sides of these first triangles. By this means extreme points on the property were laid down in the correct relationship to one another. The pit shafts were all near the verticals of these triangles, and a short measurement and bearing was all that was wanted to put them on to the plan. It next became necessary to survey the boundaries of the different estates, and it may here be said that unless very long sights can be taken and short ones avoided there is no better method of traversing a boundary than the ordinary loose needle method, providing the operator can make proper use of his vernier in reading the bearings, and can steer clear of magnetic attraction, which is not generally difficult in surveying colliery properties. This traversing is carried on between the different points laid down by the triangulation. With regard to laying down the underground roads on the plan the best plan of course where shafts at a considerable distance apart are available, is to connect the survey with the two shafts, plot it on tracing paper, and lay the survey down on the plan in position by fitting the shafts on the underground survey on the position of the shafts on the plan, and mark the survey on the plan in that position. Where it is only possible to survey between shafts not more than 30 or 40 yards apart, it is better to rely on the magnetic needle, taking loose needle readings at the beginning and end of the survey, and as often else as may be possible, and doing the work generally fast needle. At the coal face is the best place to obtain a loose needle bearing, as being newly opened there is little or no likelihood of iron lying concealed there. On the other hand, in the roads near the pit bottom, there is always a possibility of rails or water pipes lying buried there and forgotten, so that the greatest care must be taken in seeing that there is no iron lying within at least five yards of the dial when a loose needle bearing is being read.

To lay down a survey based on the loose needle on the plan it is necessary to take a needle reading between the points on the surface, which are marked on the plan, the further away the better. By this means an angetic north line ean then be shown on the plan, and by its aid the underground survey can be plotted. Care must be taken that the surface bearing must be read about the same time of day as the underground bearings are read, or else allowanee must be made for the diurnal variation of the needle. For the triangulation on the surface we should use a 5 or 6-inch theodolite with verniers reading to one-third of a minute, while for underground work nothing ean be better or simpler than an ordinary miner's dial with ordinary sights with vernier reading to three minutes. The latter instrument in the hands of a eapable surveyor will do good work in traversing the surface boundaries.—C.C.M.]

F. Hutchinson, W. T. Hughes (*12 marks each*).
R. J. Edwards (*8 marks*).

Colliery Re-opening.

Q. 10.—*You are called upon to supervise the re-opening of a colliery which has been sealed owing to fire. The seam is fiery. How would you proceed?*

A.—In proceeding to re-open a colliery which has been sealed owing to the breaking out of a gob-fire there are many factors of importance to be carefully considered, *i.e.*, the locality of the outbreak, extent and dimensions of the fire, and also the means adopted for extinction before it was decided to seal off the fire. Every precaution should be observed during the operation of re-opening, and only skilled or trustworthy men employed in the undertaking.

Personally I should proceed with the re-opening during holidays, as the men would be allowed more leisure whilst engaged in the work, and this should not be despised. Of course, if the whole of the mine was sealed off, the task of re-opening could be proceeded with at any convenient time, that is, after an adequate amount of time had passed since the sealing off occurred.

It will be obvious to most mining students that the operation of re-opening is to say the least a dangerous one, inasmuch as the fire would still continue to burn for a certain period even after the sealing off was performed. The gases and fumes resulting from the fire would be confined, and if the fire was at all extensive there would be an enormous pressure exerted upon the dams. Recognising this fact, it would be foolhardy if the work proceeded without due attention to the existing circumstances.

Having chosen the men to proceed with the undertaking, I should give them a thorough understanding as to the nature of the work they are called upon to perform, and should detail them off in gangs, so as to act in relays. Every man should possess a safety-lamp, and I should have a few spare safety-lamps ready for immediate use, and also a few electric lamps so as to provide better illumination.

The first gang of men would proceed to the site of the return dam, carrying with them the necessary tools, and also in addition to the lamps mentioned above a sufficient supply of restoratives so as to be ready for cases of emergency, such as would occur should a workman be overcome by the foul gases. I should personally supervise the work, but in case of unavoidable absence appoint the necessary officials, choosing the trustworthy men. However, after having taken due precautions to see that no person is stationed or allowed to travel in the return air-way, I should instruct the men to carefully open the return dam, having of course seen that the men are supplied with a current of fresh air, and that they work on the intake side of the brattice. The task of opening the return dam should not be performed in a haphazard manner, because if the opening was made too large a heavy quantity of gas may escape, and thus vitiate the air to such an extent as to render it difficult to dilute, and also to make it extremely dangerous to the men employed. Taking this into consideration, I should see that a small hole was bored through the dam. Immediately the perforation was made a tight fitting wrought-iron pipe should follow the drill upon which a valve and pressure gauge are attached. By means of the valve samples of the gases confined behind the dam may be taken. I should constantly allow small quantities of the gases to escape, so that they may be diluted without much difficulty, and in this way greatly minimise the risk of danger. The gases allowed to escape should be coursed directly to the main return.

The work should be accomplished with relays, one set of men resting in fresh air whilst the other set are at work. If the men off work are within hailing distance so much the better, but if they are resting at a considerable distance from those at work, a signalling apparatus and special signal should be arranged, so that in cases of emergency the men resting could be brought to the site of the dam without undue delay.

As the gases confined behind the dam are allowed to gradually escape, the pressure as registered by the pressure gauge will drop accordingly, until the gauge indicates a zero pressure.

When this occurs I should make all the necessary arrangements for opening the dam completely. As a further safety precaution I should have a few canaries or white mice, so as to detect the presence of the CO before the men had become seriously affected by it. Also for exploration work, &c., a gang of trained men equipped with the necessary breathing apparatus may be exceedingly useful, or for cases of emergency, such as where a man was "gassed."

Having seen to the provision of the necessary supply of fresh air, and also the brattice, air pipes, &c., I would give instructions for a large aperture to be made in the dam. Immediately this was done I would withdraw the men into the intake side of the brattice, until the gases exuding from the aperture had been tested by means of the safety-lamp and the white mice or canaries, paying special attention to the latter.

When I considered it safe enough for the purpose (assuming no men with breathing apparatus are employed on the job) I would make my way through the aperture, accompanied by a suitable number of men with safety-lamps, and carrying the gas-testing paraphernalia, and also a thermometer. An adequate amount of air should be provided, and this could be carried forward by means of air-pipes, so that any gases still confined could be more easily diluted. As the work of exploration proceeded, the behaviour of the white mice or canaries should be carefully noted, so as to detect the presence of the CO. It would be necessary to keep a careful look-out as to the condition of the roof and sides, because if the workings have been sealed off for any considerable period of time the roof and sides become loose and in dangerous condition. Where supports are necessary they should be put in, using as little timber as possible, iron props and bars being preferable, so that if a precipitate retreat is necessary it can be safely accomplised. As the work proceeds any inflammable *debris* which is found and likely to fire spontaneously should be sent out of the mine. The thermometer must be constantly referred to, because if the fire had only been subdued and not extinguished it may break out again with redoubled energy. Upon arriving at the site of the fire attention must be given to the thermometer so as to detect any rise in temperature, and also to any gases that may be given off, so as to ascertain if the fire is still in progress. If it was still smouldering I should take adequate precautions not to bring the air current to bear upon it, the reason being obvious. I should, if the fire was still smouldering, make a careful inspection and consider whether it would be advisable to attack the fire, or to retreat and again seal off the fire, the latter being an easy proceeding, seeing that only a small aperture has been made in the dam. If the fire was extinguished I should cool the site of it by the use of water, remove all material likely to fire spontaneously, and carefully pack tight with dry sand.

When this has been done and all danger of the fire again breaking out obviated, the return dam may be completely opened and also the intake dam. The district or districts should be opened out gradually, but special watch must be exercised over the site of the fire for a few days. The fan should be run at a very slow speed for a while, so that the returns are not fouled by rushes of practically undiluted gases, and also as an extra precaution in case the fire may be unknowingly smouldering. The above are the main precautions to be taken, but of course the person in charge would be guided in the methods adopted by the existing circumstances.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

F. Hutchinson, A. B. Dawson (*12 marks each*).
G. Lancaster, R. J. Edwards (*8 marks each*).

Ropes.

Q. 11.—*Give sketches of a socket for a winding rope, load 10 tons.*

A.—Different methods have been and are employed for socketing or capping winding ropes. Some of them owing to tests having proved that they are little more than 50 per cent. the strength of the rope, have been condemned, while others are unsuitable for the great loads now raised from some of our mines. In my answer I propose to deal with two kinds of socketings or cappings, namely—(1) The ordinary conical cap; (2) the shell bottle or solid cap.

In the first method a bar is obtained of the best material possible, square in section, and of a size according to the strength required. The necessary length is cut from this bar of iron and the ends flattened and drawn out, and afterwards hollowed out and moulded so as to form a recess for the rope. The middle portion is allowed to remain as in the bar; and when bent at this point the two ends or sides, or the hollows in the two ends, are brought face to face to ensure an accurate fit of the rope; they are then held apart pending their application to the rope, and the central portion is moulded into circular section for the application of the cage chains. The ends and also the required number of glands are forged with a suitable taper, which is not too abrupt to prevent them slipping back.

When the cap is ready for the rope the end of the rope is carefully examined for any defect, and none being discovered the requisite number of glands (usually three to four) and conical plug are then threaded on to the rope, the smaller sizes of glands going first and the plug last. Reference to *Figure 1* in No. 1 Method will soon give an idea of the method of capping. From 9 to 12 inches from the end of the rope galvanised or copper wire is wrapped, (*B*) in *Figure 1*, to a distance slightly beyond the length of the cap. Then 9 to 12 inches of the rope at the end which is unwrapped is then untwisted, and every alternate wire or strand cut shorter than its neighbour; the wires are then bent upon the edges of the wrapping, the plug brought down the rope as shown in *E*, *Figure 2*. The wires are then bent back upon the rope (*C*) *Figure 1*, and thus, with the wires previously cut, a cone is formed. The whole is now wrapped with a small tarred rope called "marlin," and the end of the rope assumes the shape of the iron cap, which is now made hot to mould to the rope more readily, and hammered down tightly upon the prepared end. The largest gland is now brought down and tightly secured, the next largest the same, and so on, the smallest gland coming last. Each gland is equally separated upon the cap. This capping has its weakness at the part where the wires are turned back to form the cone; these wires give way, and the body of the rope is pulled through the capping. The one aim in the capping of a winding rope should be to have the capping equal at least, to give a resistance equal to the breaking of the rope itself, and in the above method this is not generally attained, although is it a capping which is much used.

In *Figure 1*, Method 1, the bending back of the wires and general appearance inside the cone are shown. *A*, rope; *B*, rope wrapped with wire and marlin; *C*, wires bent back.

Figure 2 shows the position of the plug. *A*, rope; *D*, wrapping; *E*, plug.

Figure 3 shows the method when complete. *A*, rope; *GHK*, glands; *F*, cap; *L*, aperture for cage chains.

In No. 2 Method, or the solid cap, an "ideal" capping is found, and it is the one I prefer for a load as stated in the question. This form of capping is shown in *Figures 1* and *2*, No. 2 Method. It consists of a conical shaped socket forged from a solid piece of steel, with a composition of white metal run around the wires to form a cone, fitting perfectly into the conical shaped cap. This capping is stronger than the rope itself, tests having proved that the rope has been known to break first. It is also considered to be the simplest, strongest, and safest capping known. The process of capping is simplicity itself, and can be done in about a quarter of the time that it takes with other forms of cappings.

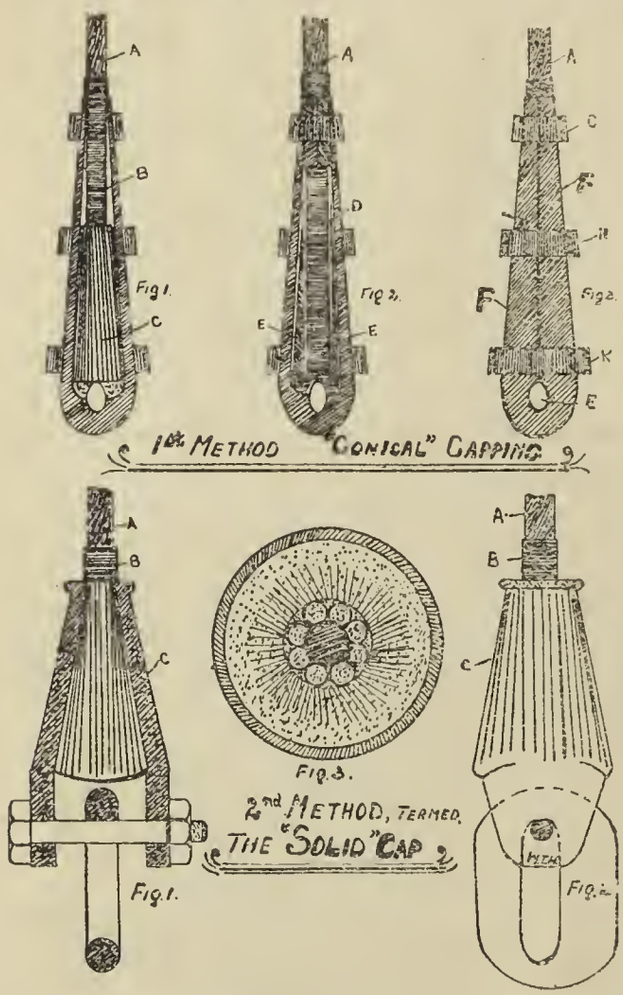
In this method great skill and care are required to adjust the cap satisfactorily. The cap is threaded on to the rope, and the rope at the end is left unwrapped, but is wrapped with wire from this point to a distance slightly beyond the length of the cap. By referring to sketch an idea will be formed of the process of capping with this method. The first step is to thread the conical cap *C*, *Figure 1*, on to the rope *A*; then soft copper wire, *B*, is wrapped round the rope as stated above. The wires of the rope for this short length are opened out, straightened, slightly hooked at the ends, and thoroughly cleaned with hydrochloric acid or paraffin, to remove the oil, with which every rope is covered. The end is next drawn into the socket, which is afterwards completely filled in with white metal, *D*, consisting of 60 per cent. lead, 30 per cent. tin, 9 per cent. antimony, and 1 per cent. bismuth. The bismuth in the mixture lowers the temperature of fusion, and is supposed to give a slight expansion in cooling, while the antimony adds to the hardness. It may be argued that the temperature of the molten metal injures the wires, but we have it on good

authority that steel wire, if not previously hammered or worked, is not affected up to a temperature of 900° Fah., while the temperature of the molten mixture never exceeds 500° Fah.

Before the cap is placed on the rope it is slightly warmed, also when all the wires have been cleaned, no two wires permitted to be together. A resinous dust is blown in among the wires to ensure adhesion of the metal about to be poured in.

The cap should be left after the metal has been poured in, say about an hour to cool before being put into use.

This is an "ideal" socket for a winding rope, and one able to cope with the load in question.



Illustrating Question 11.

Figure 3 gives an enlarged view of bottom of rope with wires bent out, not back, and how the cap is filled with white metal.

W. T. Hughes, 103, Wigan Road, Ashton-in-Makerfield.

[NOTE.—Undoubtedly the best capping for a winding rope where any considerable weight is to be lifted is the solid or white metal capping described above. The strength of this capping more nearly approximates to that of the rope itself than does that of any other form of capping.—C.C.M.]

W. Heys, F. Hutchinson, A. B. Dawson (*12 marks each*).
R. J. Edwards (*8 marks*).

Electrical Apparatus.

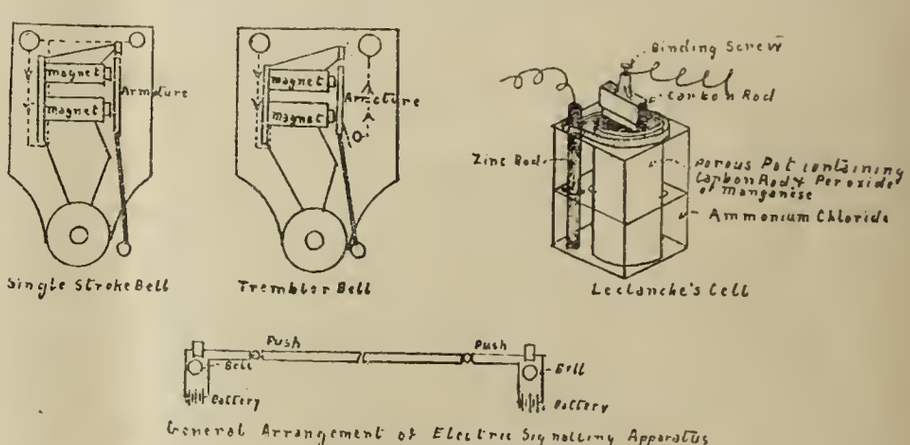
Q. 12.—*Describe the apparatus necessary for electric signalling on a plane 3 miles long. What precaution would you take in fixing same in a gassy mine?*

A.—(1). *Bells.*—These are of two different types, known as the "Single Stroke" and "Trembler," each having certain advantages as follows: The trembler bell is better for indicating when the wires are crossed, &c., as continuous ringing takes place until the wires are put in order, or the bell switched off; but the single stroke is safer in a gassy mine, as in the trembler type the electric circuit is "made" and "broken" in rapid alternations, a slight spark being made on each contact of the armature and electro-magnet. (See *Figures 1* and *2*).

(2). *The Battery.*—This consists usually of two Leclanche cells, each cell being filled three parts full with water, and supplied with the usual carbon stick, porous pot, zinc rod, sal-ammoniac, &c. These cells are all coupled together in "series," giving us a total pressure at the battery of 15 volts. (This pressure must not be exceeded in any one signalling circuit under the present Act, but under the new Electrical Special Rules 25 volts is allowed).

(3). *The Wiring.*—This is necessary to convey the electric current to and from the bells. The circuits are metallic, *i.e.*, in some cases three wires are used, the middle wire being the common return for both, and in other cases only two wires are used. Bare galvanised wires of from No. 10 to No. 12 S.W.G. are used, and these are preferable on a road that is dry as a signal can be sent by bringing the wires in contact, bridging by means of a knife blade, piece of copper wire, &c. These wires can either be suspended from the timbers supporting the roof or taken along the side of the road, being connected to the bar legs (one above the other) about 6 inches apart, by means of porcelain insulators fixed at intervals of, say, from 12 to 15 yards apart, the wires being placed upon them and bound by a small piece of thin binding wire to keep them in their respective positions.

(4). "Ringing keys" or "push buttons" are fitted up at the top and bottom, and the different junctions of the haulage roads where signals are required to be sent from, and these along with the bells can be fixed in any part of the road to suit the purpose. See *Figure 3* which shows diagrammatically the arrangement of the wires, pusher, bells, and batteries.



Illustrating Question 12.

Precautions I should take in fixing such arrangement in a gassy mine: The bells should be enclosed in strong gas-tight casings, which should be damp and dust-proof. The wires should be kept from contact with the timber and kept tight, care being taken to have as few joints as possible. The batteries and bells should be connected by insulated copper wires, and the wires kept at such a distance from the tubs as to be unlikely to be damaged in the event of tubs breaking loose, &c. They should also be kept away from other electrical apparatus which may be fixed on the same plane.

Figures 1 and *2* show in diagrammatic form the connections inside a single stroke and trembler bell respectively. *A A* are two electro-magnets wound with fine insulated wire; *B* is a small iron armature which carries the hammers to strike the gong. The arrows indicate the direction of current through the bells.

Fred Hutchinson, 27, Longfield Road, St. Helens Road, Bolton.

W. Heys, F. Davies, W. Silverwood (*12 marks each*).
R. J. Edwards (*8 marks*).

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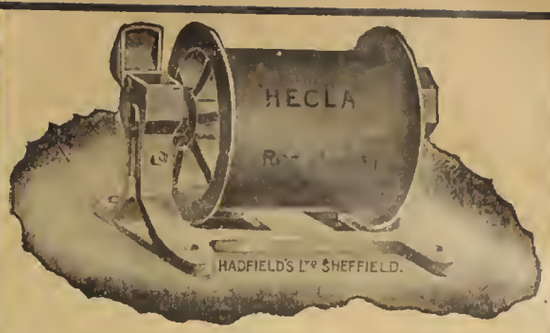

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Form of notice of accident causing loss of life or serious personal injury to be sent to representative of persons employed—section 80 (1)	48	1*d.*
Form of notice specifying the period of employment and times allowed for meals of boys, girls and women—section 93	19	1*d.*
Form of register of boys, girls and women employed—section 94	20	4*d.*
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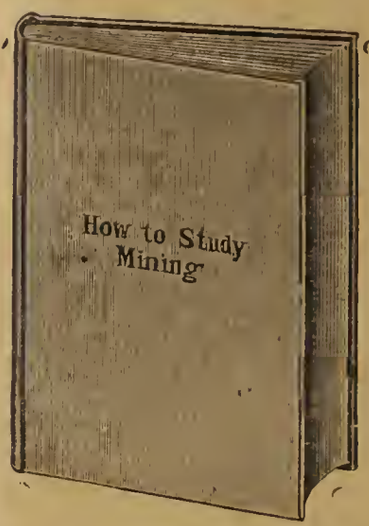

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NEWS AND NOTES.

Competition for Firemen.

At the head of the Prize Competition in this issue, the regulations for the forthcoming volume are set forth, and will we think be understood by all. A departure from the old arrangement may give general satisfaction, namely, the inclusion of a section for Colliery Firemen, Examiners or Deputies. Second Class and First Class students are also provided for. This Competition is open to all readers of *The Science and Art of Mining* who have not previously secured first place in First Class, and to gain the fullest advantage therefrom a commencement should be made with the first set of questions given. Tell all your friends at the colliery about the new Competition. A slight service like this will do you no harm and may do them a lot of good. The Firemen's section takes the place of what was the Preparatory, but elementary students will not be neglected, a special series of articles for youths entering or having lately entered the coal mines being now under preparation to commence with the new volume in August. To ensure getting this Journal regularly place an order with your newsagent for a copy to be kept for you. This is desirable, as several recent issues are already sold out, including No. 24.

Ascertaining Views of Workmen.

An Order has been issued by the Secretary of State, dated June 22nd, 1912, under Section 118 of the Coal Mines Act, 1911 (1 and 2 Geo. 5. c. 50), prescribing the procedure to be observed for ascertaining and certifying the views of workmen as follows :

(1.) In any case where the views of the workmen or any part of the workmen in any mine are required to be ascertained for any of the purposes of the Act, they shall, unless a ballot is expressly required by the Act, be ascertained by a show of hands at a meeting of the workmen entitled to vote of which not less than three days' notice shall be given by a notice posted at the pithead specifying the time and place of meeting. A certificate stating the result of the voting and signed by the person presiding at the meeting shall be forthwith delivered to the owner, agent, or manager of the mine.

(2.) If within seven days after a meeting as aforesaid the owner, agent, or manager of the mine, or not less than one-tenth of the workmen entitled to vote by signed notice served on the owner, agent, or manager, demand a ballot, or if the Secretary of State in any matter in which he is concerned by notice served on the owner, agent, or manager, directs that a ballot shall be taken, or in any case where the Act requires a ballot to be taken, a ballot shall be taken in the manner hereafter provided.

(3.) Within 21 days after the date of the meeting or after the receipt of a notice as aforesaid as the case may be, or (in a case where the Act requires the views of the workmen to be ascertained by ballot) after receipt of a notice signed by not less than one-tenth of the persons employed at the mine that it is desired that a ballot shall be taken, the manager shall cause a register to be prepared of the workmen entitled to vote.

(4.) The register shall be open to inspection by the workmen at the mine and by the checkweigher or other representative of the workmen as hereinafter defined, for at least one week before the ballot is taken.

(5.) The taking of the ballot shall be carried out by a representative of the owner, agent, or manager, and the checkweigher or other representative of the workmen, and shall take place on the second Saturday after the completion of the register, or any earlier day agreed upon by the said representatives.

(6.) The hours during which the ballot shall be taken shall be such hours as may be agreed upon by the said representatives, or, in default of agreement, between 8 a.m. and 8 p.m.

(7.) Notice of the purpose for which and the place at which the ballot is to be taken and the day and hours fixed for the ballot shall be posted by the said representatives at the pithead not less than three days before the day fixed for the ballot.

(8.) The ballot paper shall be in the form set out in the Schedule hereto (*not reproduced*), and shall not be marked in any way whatsoever so as to identify the person voting.

(9.) A ballot paper shall be delivered by the said representatives to any person applying to them and entitled to vote, who shall forthwith mark his vote thereon, fold the paper so as to cover the mark, and deposit it in a box to be provided for the purpose.

(10.) Arrangements shall be made to enable a workman to mark his vote screened from observation.

(11.) The ballot papers shall be examined and the votes counted by the said representatives, and a certificate in the form set out in the Schedule hereto of the result of the ballot and of the total number entitled to vote shall be signed by them in duplicate : one copy to be retained by the representative of the workmen, the other copy to be delivered to the owner, agent, or manager, who in the case of any matter under Sections 86 and 87 and the Second Schedule to the Act, shall forward it forthwith to the Secretary of State.

(12.) If any dispute arises as to how any particular ballot paper shall be counted, the matter shall be referred to the Inspector of Mines for the Division, who shall decide the matter so as to give effect, as far as possible, to the intention of the person voting and whose decision shall be final.

Dyllas Valley Men Injured.

A shot-firing accident occurred at the Brynteg Colliery, situated between Glynneath and Seven Sisters, in the Dyllas Valley. Two men, Elias Jones and David Hughes, with two others, proceeded to work for the purpose of ripping top, and later in the day they charged some holes for shot-firing, and duly retired. In the belief that both shots had gone off they proceeded to return to the spot, but just as they approached it one of the shots went off. Hughes and Jones were blown off their feet by the force of the explosion, and when picked up were found to have been burnt about the head and body, the injuries to Jones being the more serious. Dr. Armstrong and Dr. Edwards, of Seven Sisters, were immediately called to the colliery, and attended to both men, who were afterwards conveyed home. The other two men fortunately escaped without injury.

Presentation to Mining Teacher.

The students of the Technical Classes at Porth and Ynyshir presented their teacher, Mr. William Thomas, with a gold pendant, &c., as a token of the esteem and regard in which the students of the above classes held him. The presentation was made by Mr. John Hughes. Mr. Thomas said he was most pleased to say that three of the Ynyshir students had passed, and been favoured with free scholarships to the Summer Mining School at Cardiff College in August next, and that they owe a deep sense of gratitude to Mr. William James Thomas, J.P., Ynyshir, for his financial support of the above classes ; at the same time they must not forget the hearty support they received from Alderman Morgan Williams, Porth. The students who have gained the scholarships are : Mr. Wm. Morgan Davies, Aberhondda Road ; Mr. Wm. Hine, William Street ; and Mr. Philip G. Griffiths, Gynor Place, Ynyshir.

COLLIERY ENGINEERING.

By CLANSMAN.

Scalar Quantities.

Some physical quantities can be adequately expressed by a number denoting so many units, *e.g.*, a number may convey to our minds a complete knowledge of the weight of a body, or its temperature or its cost. When a number conveys this definite knowledge of any quantity, that quantity is said to be *scalar*.

Vectors.

Other quantities cannot be fully represented by a number only, and if we are to have an exact conception of the value of that number further information is required, *e.g.*, if we were told that a train was running between London and Edinburgh with a velocity of 60 miles per hour our knowledge of the train's motion would be incomplete unless we were also told the direction in which the train was moving, and the place from which it had started.

We have already seen that to have a complete knowledge of a force we must know—

(1) its direction or line of action;

(2) a point in its line of action, or the point at which it is applied;

(3) its magnitude.

Any quantity that requires these three specifications to completely determine it, is called a vector quantity.

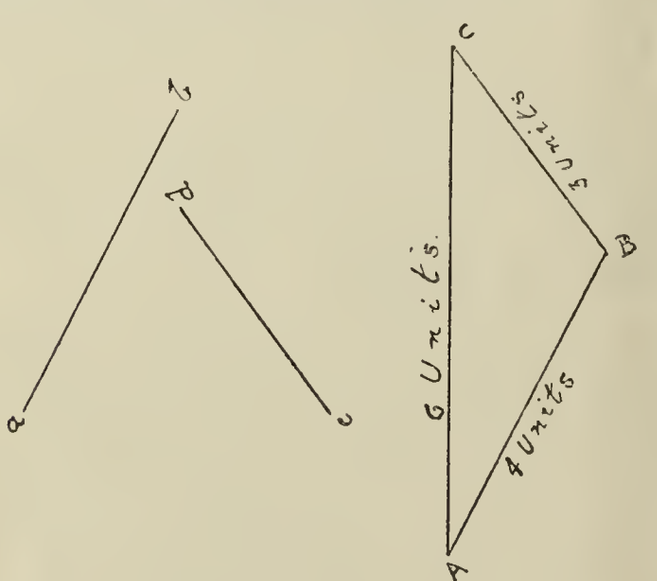


Figure 23.

The term "line of action" applied to vectors is not sufficiently explicit. For example, if a vector be represented by a vertical line the direction along that line may be either upwards or downwards. Hence what is called the *sense* of a vector is used, and if we include *sense*, four things require to be known before a vector is completely specified.

Addition of Vectors.—To find the sum of two vector quantities represented by the lines *ab* and *cd* (*Figure 23*), draw *AB* parallel and equal in length to *ab*, and from the end *B* draw *BC* parallel and equal in length to *cd*. Then *AC* is the vector sum of *ab* and *cd*.

This may be written thus: $AB + BC = AC$; or since *BC* is equal to *cd*, $ab + cd = ac$.

Note that the sum is *AC* not *CA*.

Subtraction of Vectors.—To subtract the vector *cd* (*Figure 24*) from the vector *ab* draw *AB* equal in length and parallel to *ab*, then from the end *B* draw *BC* equal in length and parallel to *cd*, but placing the end *d* instead of *c* on the end *b*. That is, draw *BC* in the opposite direction to that taken in addition in *Figure 23*.

Then $AE = AB + BC = ab - cd$.

Let us take another vector quantity—*a displacement*—and see how it may be represented by a vector; and we shall also observe how one displacement may be added to or subtracted from another. If we take this paper and carry it to a place 1 yard due north from where it is now, the paper will have been displaced by 1 yard; but we notice that the displacement is not defined by the magnitude 1 yard; it must also be due north, and, further, it must be measured from the point from which the displacement began.

Thus the displacement is fully represented by a straight line 1 yard long, pointing in the direction of due north, and passing through the point where the displacement began. We can represent this graphically on paper by choosing a point *A* to represent the starting point, drawing through it a line *AB* pointing in the direction we choose for north, and making *AB*, say 1 inch long, that is, making the scale 1 inch to the yard.

If now we carry the paper from *B* one yard towards *C* in a south-west direction, this displacement may also be represented by the line *BC*, and the result of giving the paper first the one displacement and then the other is to give it a final displacement represented by the line *AC*. This line *AC* is called the sum of the two vectors, and we see that we may sum the vectors by merely drawing them to the proper scale and in the proper positions, and then measuring the length and noting the direction of the line drawn from the point where we commence to the point where we finish. If after carrying the paper 1 yard north

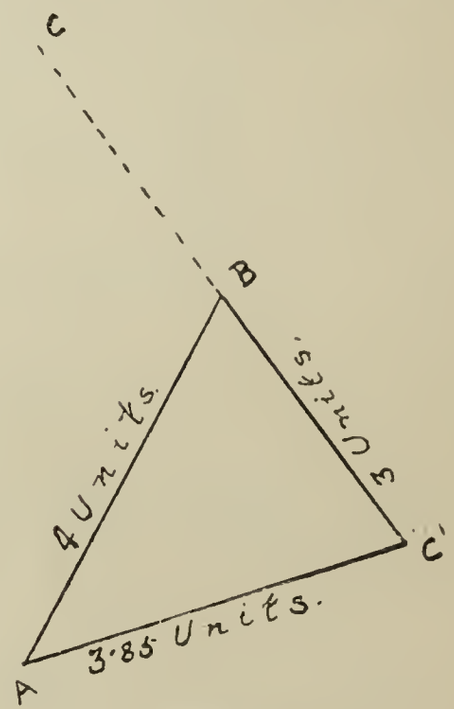


Figure 24.

we then had carried it one yard south, it is clear this latter displacement would have cancelled the first one, and the paper would be again at the starting place. In this case we would say the vector sum is zero. If we give the sign + to the displacement along the line *AB* towards the north, and the sign — to that towards the south, we know that the vector sum is zero and we write it thus: The displacements along *AB* of $+ 1 + (- 1) = 0$.

From this we see that we may subtract one vector from another by adding to the first a vector equal to the second, but of the opposite sense, that is, drawn in the opposite direction. This follows because $+ 1 - (+ 1) = 0$, is the same as $+ 1 + (- 1) = 0$.

If then we wish to subtract the vector *cd* from the vector *ab* (*Figure 24*) we do so graphically by drawing *AB* in position to scale, then drawing *BC* in position; but measured back in the opposite direction BC^1; and then joining AC^1, when AC^1 will be the vector difference.

The reader will have no difficulty in understanding this if he thinks of himself as first going a mile north from *A* to *B*,

and then saying that he wishes to shift his position so that he may go a mile further from the north-west than he is when at *B*. Here, nearer to, would have the + sign, and further from, the — sign.

We may note that the sum or the difference of any number of vector quantities may be obtained by carrying on the above process, and also that the result or *resultant*, as it is called, will itself in every case be a single vector quantity.

When a body undergoes two displacements at the same time, the position finally reached will be the same as if the body had undergone first the one and then the other displacement.

At every instant while the change of displacement is taking place, the position of the body will be that due to the addition of the fractions of the total displacements corresponding to the particular instant. In this way it is seen that the body moves along the path given by the line which represents the resultant displacement. As an example, consider a man walking 20 feet in 5 seconds, across the deck of a ship which moves forward in the same time a distance of 80 feet. We will suppose the

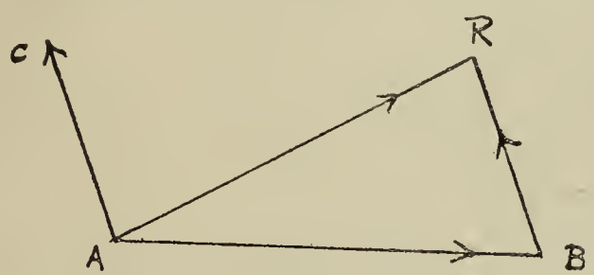


Figure 25.

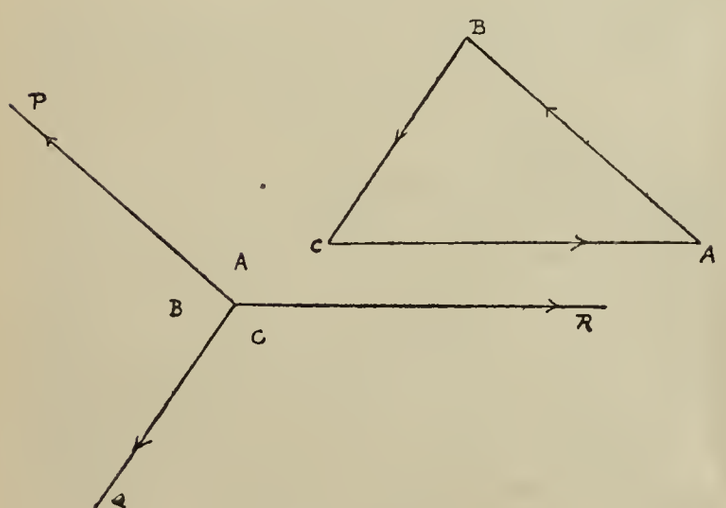


Figure 26.

ship moves west, and the man travels towards the south. After 5 seconds the man's position will be 80 feet to the west, and 20 feet to the south of the initial starting point, which is the same as if he had first undergone a displacement equal to that of the ship, and then a displacement of 20 feet to the south. After one second the man's position will be 16 feet to the west, and 4 feet to the south of the initial point, and so on for other instants. Thus the man occupies successive positions along the line of the resultant. Now when we consider a displacement as occurring in a given time, we have a velocity. Velocities therefore obey the vector laws of addition and subtraction. The same laws will also apply to the compounding of velocities which are imparted to a body in the unit of time. But it is an experimental law that a velocity imparted to a body in the unit of time, *i.e.*, an acceleration, is proportional to the force which produces it. Thus forces also compound in accordance with the vector laws. Applying this to forces, we observe that two equal forces acting through the same point and in the same direction will give a single vector in the same position and direction, of twice the length; while, had the forces been of opposite sense, the resultant would have been zero. When the forces acting at a point are inclined to each other, the resultant is obtained by the law of vector addition. This gives us the graphical figure called the *triangle of forces*. Thus the forces *AB* (*Figure 25*) and *AC* acting through the point *A* are equivalent to the force represented by *AR*.

If there was another force acting through *A* equal and opposite to *AR*, the resultant would be zero. In that case we speak of the force *RA* as being the equilibriant of the other two forces. Here we should have three forces acting through the point *A*, and their resultant would be zero. If *A* were a point in a body the body would be in a condition of internal stress by the application of the forces, but the body as a whole would not tend to move, as the resultant force equals zero.

We may state the converse proposition, viz.: If a body under the action of three forces does not change its motion, or its condition of rest, then the three forces may be represented in magnitude and direction by the three sides of a triangle taken in order.

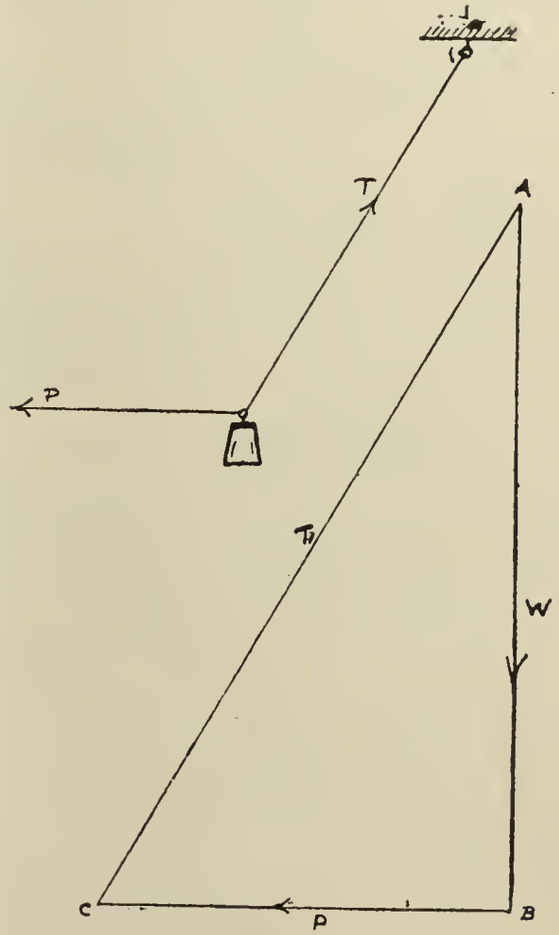


Figure 27.

Thus forces *P*, *Q* and *R* (*Figure 26*) are 4, 5 and 6lb. respectively. When *AB* is drawn parallel to *P* and equal to 4 units; *BC* is drawn parallel to *Q*, and equal to 5 units; and *CA* is drawn parallel to *R*, and equal to 6 units, they form the triangle *ABC*.

As an example of the application of this law consider a weight *W* of 50lb. supported by a string which makes an angle of 30° with the vertical, and by a horizontal pull *P*. We wish to determine the forces *P* and *T*. The force of 50lb. due to gravity acts through the centre of the weight. Draw *AB* vertically downwards, and make *AB* = 5 inches, *i.e.*, to a scale of 1 inch = 10lb. (*Figure 27*). Through *B* draw *BC* parallel to the force *P* and through *A* draw *AC* parallel to *T*. Then *BC* and *CA* will represent *P* and *T* respectively to scale. If the reader will plot these forces to the scale mentioned he will find that *BC* measures 2·88 inches and *CA* measures 5·77 inches. Hence the horizontal pull *P* = 28·8lb., and the tension in the string *T* = 57·7lb.

MINE GASES AND GAS TESTING.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

By M.E.

No. 10.—Fires and Explosives.

In addition to natural gases and those produced by explosions it is necessary to take into consideration the gases which may result from an underground fire, or a fire in or about the downcast shaft, and those resulting from the use of explosives.

In all cases of the combustion of carbonaceous material such as coal, and timber, carbon dioxide and water vapour are formed. In cases where the air supply is limited some *carbon monoxide* is produced, the quantity varying with the readiness with which the oxygen from the air can get in intimate contact with the consuming carbon. In addition to these products there may be produced large volumes of irritating fumes consisting of unconsumed vapours distilled from the burning material. Thus the *smoke* arising from a fire may be an exceedingly complex mixture of gases and vapours.

Apart from the physical distress that may be produced by the irritant action of the fumes, the chief danger to life underground arising from a fire in or about the downcast shaft or intake air-ways, is due to the carbon monoxide which the smoke is almost certain to contain. The physiological effects of this gas have already been discussed in a previous article, and reference should be made to this.

The prevention of fires at the surface near to the mouth of the downcast shaft, or in the shaft itself, or at the bottom of the shaft, usually lies outside the duties of the deputy. An outbreak of fire at such places would, however, immediately foul the air-current passing into the mine, and, assuming the men were in the pit, would create a situation demanding the urgent attention of the deputy.

As a rule each case of fire creates its own problems, but in all cases the guiding principle should be to restrict the poison laden air to the smallest part of the mine that is practicable by opening separation doors, or breaking down selected stoppings, at the most accessible points near the seat of the fire.

In the case of a serious fire this will have the effect of fouling both shafts and, in the case of a fire in an intake air-way, both roadways leading to the shafts. Some judgment requires to be used, therefore, in such circumstances as to whether men inside the mine should attempt to escape to the shafts, or should remain in the mine and attempt to protect themselves from the poisonous air by suitably short circuiting the air-current and retiring *from* the main air-ways. In order to make such restraint easier, it is very desirable that all mines should be equipped with telephone communication from all parts of the mine to the surface, so that men in the mine may know exactly what is being done at the surface.

In cases of fire in or about the shafts, the question of the reversal of the air-current will probably arise. Should this be decided on by the management at the surface the deputy will probably have to give some attention to the effects which this action will have on the circulation of the air in and about the workings, particularly so if there are open wastes or old workings likely to contain accumulations of fire-damp.

In all dry mines open lights should be totally prohibited, even in the absence of fire-damp, in order to avoid the accidental ignition of timber, brattice cloth, &c.; and in no mine should oil be allowed to accumulate at any haulage gear or engine. The use of timber to support haulage wheels or pulleys should be avoided, as far as is practicable, as the wood is likely to absorb oil from the bearings and thereby become a potential source of danger.

Wherever possible non-combustible material should be used for all structures and fittings, and, where it is necessary to store combustible material, an ample supply of chemical extinguishers and sand should be available for use if a sufficient supply of water cannot be provided.

Pillar fires and gob-fires, arising from the spontaneous ignition of the coal or associated strata, are not as a rule so immediately dangerous to life as a conflagration, though often quite as expensive from the property point of view.

Spontaneous combustion arises chiefly from the absorption of oxygen by the coal or carbonaceous shale. Indirectly it is assisted by roof pressure, by air leakage through badly-built packs, and by the decomposition, in the presence of moisture, of some forms of iron pyrites.

Oxygen from the air combines with hydrogen in the coal to form water vapour. In this reaction a certain amount of heat is generated, which, unless it is carried off in the air-current, tends to raise the temperature of the coal.

Oxygen also combines with the carbon in the coal to form one or other of the two oxides of carbon, usually giving off more carbon dioxide than *carbon monoxide*.

As is the case with hydrogen this combination with carbon gives off heat. The heat generated in this way is exactly similar in nature to that generated by the combustion of coal in a household fire, the higher *temperature* of the latter being due entirely to the higher rate of oxidation of the coal.

It is interesting to note that the development of a large amount of heat does not necessarily mean the development of a high temperature. If the heat developed by the oxidation of coal is carried off as fast as it is developed the temperature of the coal cannot be increased. On the other hand if the heat is allowed to accumulate in the vicinity of its generation, the temperature will undoubtedly rise and may rise sufficiently high to ignite the coal. It is due to this fact than an incipient pillar fire may often be got in hand by increasing the quantity of air passing the heated parts so as to carry off the heat as it is generated.

It is important to note that the rate of oxidation of coal increases as the temperature increases, so that once a coal starts to heat up there is every possibility of a rapid rise of temperature. The initial signs of heating should therefore be considered of importance.

Usually the first sign of a heating gob is the deposition of moisture in its vicinity resulting from the combination of oxygen with the hydrogen of the coal. This is soon followed by the emission of "fire stink"—a characteristic odour probably due to the emission of low temperature hydro-carbons. Accompanying this is the production of carbon dioxide and carbon monoxide in varying quantities.

In the prevention of spontaneous combustion the fireman, examiner, or deputy, has a good deal of responsibility in those districts which are subject to such fires.

In pillar workings it is very important to avoid the exposure of small pillars, or corners of pillars, to crush by the roof pressure. This is particularly important with reference to pillars between the intake and return air-ways. Such pillars may develop lateral fissures, through which air may leak owing to the difference of pressure between the intake and return side of the pillars. As such fissures usually contain much finely powdered coal the conditions are specially favourable to spontaneous heating.

For similar reasons care must be taken in fixing the position of separation doors, stoppings and regulators, as owing to the difference of pressure which exists between the two sides air may leak through fissures in the pillars and give rise to trouble. In such cases of heating an outlook should be kept for carbon monoxide.

In order to prevent spontaneous heating in the gobs all slack should be sent out of the pit and an attempt made to exclude the air from the gobs by building good pack walls. This latter point is important. The writer is aware of several cases of gob-fires which undoubtedly arose owing to the negligence of the under-officials concerning the roadside packs.

All back timber should be withdrawn in seams subject to spontaneous combustion, and a straight face kept to encourage the regular settlement of the roof. Irregular settlement leads to the development of breaks and fissures in the roof which may give access to the centre of the gob, thereby rendering ineffective the efforts to exclude the air by well-built pack walls.

Back timber, when left standing, also encourages the formation of pockets of air in the gob, leading to oxidation if the subject is favourable. Owing to its comparatively low ignition temperature such timber often bursts into flame during the operation of digging out a gob-fire in its early stages, and may thereby give rise to much difficulty and danger.

The danger to life when dealing with gob or pillar fires is due,

chiefly, to the existence of carbon monoxide in the gases given off. Extreme care should be taken therefore that no person is subjected to the possible risk of poisoning.

When digging out a fire, or damming one off, the persons most immediately in contact with the work should be provided with smoke helmets, or self-contained breathing apparatus. All others should have a fresh air supply provided by means of air-pipes or brattice.

In gassy seams which are subject to spontaneous combustion the utmost care must be taken to avoid accumulations of fire-damp and the development of spontaneous heating. Such a combination of circumstances is particularly risky, and much responsibility rests upon the deputies in charge of such seams or districts, as safety can be secured only by the adoption of effective preventive measures which, in all probability, they will have to supervise.

Details which, in other circumstances, might be considered trivial, may in this connection be exceedingly important in their possible effects. Should such a spontaneous fire get out of hand and approach the incandescent stage, it is almost inevitable that an explosion will result immediately an attempt is made to shut off the air supply so as to extinguish the fire.

While the fire-damp may be given off at a constant rate, the diminished air supply caused by the erection of fire-dams, will permit the *percentage* of fire-damp behind the dams to increase to within the explosive limit; hence the extreme danger.

In such circumstances it is evident that whatever is done to control or extinguish the fire must be done quickly, with as few men in the pit as possible, and these must be cleared out at the earliest possible moment in view of the possibility of an explosion of the gradually accumulating fire-damp.

The best safeguard against such risks is a staff of highly skilled under officials, who can be depended on to conscientiously supervise every operation that may have even a remote influence on the spontaneous heating of the coal, or of the gob, or which in any way affects the efficiency of the ventilation.

Replies by M.E. to Correspondents.

Constant Reader.—In accordance with Section 15—1 (*a*) a person holding a first or second class certificate under the Coal Mines Act, 1911, may act as a fireman, examiner, deputy, or shot-firer without further examination. Certificates of competency granted under the Coal Mines Regulation Act, 1887, have the same value as the corresponding certificates under the new Act. See Section 126 (*a*).

E.E. (*Ammanford*).—I trust you recognise your reply under these initials. Answers can only be given through the medium of the Journal, and not by post.

As no provision is made in the sub-section for any delay, Section 43 (2) is now in operation in accordance with Section 127 (2).

It would appear from Section 43, 2 (*b*) that the manager *or* under-manager can give written permission for a person to ride on a "full set of tubs" at the end or commencement of the shift if he (the official) cares to accept the risk. A written permit will be necessary for each individual proposing to ride. It is probable that should such written consent be given, Sections 46 (4) (*c*), 57 (4), and 66 will come into operation for these roads. There is some doubt however as to whether riding on tubs up or down an incline underground is "raising or lowering persons" within the meaning of the Act. In all probability regulations will be made covering this matter, under the provisions of Section 86 and 87, which will have effect as if enacted in the Act.

F. O. (*Netherton*).—If you do not wish your name to appear, please use a pen-name *in addition* to the full name and address.

The Coal Mines Act, 1911, applies to all mines of coal, mines of stratified ironstone, mines of shale, and mines of fire-clay. I am not aware of such a thing as a "Small Mines Bill." Reference is made in several sections of the new Act to small mines, but the meaning of the term "small mine" is carefully defined in Section 122, fifth paragraph.

W. A. (*Motherwell*).—In order to obtain a fireman's certificate you will require to show how you would test for gas; and also to determine practically by the use of safety-lamps, the percentage of gas in various mixtures of gas and air, which the examiners will make up for the purpose. The relation of the height of cap produced by a percentage of gas is not fixed, but varies with the condition of the test flame. Hence any table of gas caps for given percentages is usually misleading. Read the article on *Flame Tests for Fire-Damp*, published in this Journal on April 13th, 1912.

An Eager One.—The term "firemen, examiners, or deputies," is used to indicate the competent persons that are necessary to carry out the statutory duties mentioned in Section 14 (1).

The compound expression must be used in order to include all persons whose duties are referred to in Section 14. This is partly due to the limitations of language, and the fact that not one of the three words used has a clearly defined meaning that is accepted in the same sense in all mining districts. You will probably have heard of certain gentlemen—very estimable and eager ones—who, for a consideration, would be delighted to discuss in the law courts the simple problem as to "when a deputy is not a deputy," or when a fireman is a shot-firer, a person who looks after fire-damp, one who attends gob-fires, or one interested in the generation of steam. An Act of Parliament is interpreted in the law courts in accordance with the words used in the Act, and not necessarily in accordance with the intentions of the persons who passed the Act, hence the importance of using inclusive and accurate terms, even though these are clumsy, when drafting the Bill. If you think on these lines you will see the necessity of the combination "fireman, examiner, or deputy."

Black Watch.—Section 44 (3) (*b*) should not give much doubt as to its meaning. In normal sized roads the refuge holes must be the height of the road at the point where the refuge hole is made. In roads that are over six feet in height, the man-holes need not be more than six feet high. Thus in a road four feet high the refuge holes must be not less than four feet high. In a road eight feet high the refuge holes need be not more than six feet high.

A SHOT-FIRING ACCIDENT.

A shot-firing explosion in the New Delaval resulted in serious injuries to Aaron Walton. Walton was stemming a charge of gunpowder when it prematurely exploded, and he was burned about the head, face, and arms. Walton is secretary to the New Delaval miners, a delegate for Northumberland to the National Federation Conferences, a trustee of Ruskin College, and a leading official of the Plebs League. He is regarded as one of the most promising young men in the ranks of the Northumberland Miners' Association.

RECENT LEGISLATION DISCUSSED.

A general meeting of the National Association of Colliery Managers (Scottish Branch) was held in the Heriot Watt College, Edinburgh. The President (Mr. Charles C. Reid, Fife) in the course of his address, referred to the services rendered by Mr Gibb, Glasgow, the past-president, and said that the history of the association itself was simply the history of Mr. Gibb's connection with it. In regard to the Coal Mines Act, he said that there were a great many points connected with it with which they did not agree, even on the ground of safety, but the Act contained many provisions which certainly added to the security of mines. As colliery managers they must simply accept the law and loyally carry out its provisions. He put before them a few points in mining in reference to the additional costs which would be met with in the operation of these Acts. It was the duty of colliery managers to reorganise their forces with the view of at least meeting these charges, which must come out of the industry in some way. If those connected with the production of coal had done their best on the introduction of new machinery and the reorganisation of the forces at their disposal, and the coal industry, by reason of the burdens which had been laid upon it, failed to make an adequate return for the capital which had been invested in it, they as colliery managers should at least have done their best. There were now 208 members belonging to their association, and they were equal with the second branch in point of numbers, their branch having been in existence for three years only.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Q.—A mine is ventilated by a furnace, which produces a current of 200,000 cubic feet of air per minute with a 2½ inch W.G.; you are required to replace the furnace by a fan to produce a current of 300,000 cubic feet per minute. Show how you would arrange the work, and draw up specifications of fan and fan engine that you would employ.—Submitted by "E."

A.—Before one can enter into specifications of the proposed fan and fan engine, one must notice data other than those presented to him in the question alone. The quantity produced by the furnace is 200,000 cubic feet of air per minute, with a 2½-inch W.G., presumably at the furnace drift. Assuming the air-ways to remain the same, what will be the W.G. to pass 300,000 cubic feet? The ventilating pressure varies directly as the square of the quantity, therefore

As $200000^2 : 300000^2 :: 2\frac{1}{2}$ inches $: x$ inches.

$$\therefore \quad 2^2 : 3^2 :: 2{\cdot}5 : x.$$

$$\therefore \quad 4 : 9 :: \frac{2{\cdot}5 \times 9}{4} = 5{\cdot}625.$$

Therefore to pass 300,000 cubic feet of air per minute through the same air-ways will require a ventilating pressure equal to 5·625 inches W.G. at the separation doors underground.

Without calculating shaft friction, and since no shaft data are given, we may assume the water-gauge at the fan drift to be equal to 5·625 inches, or even 6 inches, according to size and depth of shaft.

It is necessary here to ascertain the horse-power of the air, for it will be seen that such horse-power, besides showing the actual power spent on the air, shows the useful effect of the fan employed. The H.P. as useful effect may be obtained by the formula:—

$$E = \frac{Q \times \text{W.G.} \times d}{33000}.$$

Where E = the useful effect of the fan in horse-power;
Q = the quantity of air in cubic feet per minute exhausted by the fan;
W.G. = height of water-gauge in inches;
d = the weight of a square foot of water 1 inch deep = 5·2lb.

Then, substituting values,

$$E = \frac{300000 \times 6 \times 5{\cdot}2}{33000} = 284 \text{ H.P.}$$

It should be noted that the depression of the air in a mine, whether affected by a fan, furnace, or any other means, may be likened to a height of displacement of water in the water-gauge, or of a column of air constituting the motive column, being of the same temperature and atmospheric pressure as the air outside the mine, and which acts with the energy due to its height upon the downcast column of air. It is this power which produces the motion of the air into the mine, which circulates it, and causes a fixed quantity to flow in the unit of time fixed upon.

Then, considering the motive column,

$$E = \frac{Q \times w \times h}{33000} = \text{horse-power.}$$

Where E = the useful effect of the fan in horse-power;
w = weight of a cubic foot of air as it enters the downcast pit;
h = the motive column expressed in feet of air column.

Under ordinary atmospheric conditions the average weight of a cubic foot of air may be taken as 0·076lb., when, since

$h = \frac{\text{W.G.} \times 5{\cdot}2}{w}$, for 1 inch of water-gauge, the height of motive column will be $\frac{5{\cdot}2}{0{\cdot}076}$ = say 68 feet.

A water-gauge of 6 inches would be equivalent to a motive column of about 68 feet × 6 inches = 408 feet, and the useful work performed by the fan would be equal to the weight of air, Qw, multiplied by the height, h, through which the "weight" is submitted.

The above horse-power gives the useful effect of the fan, *i.e.*, it shows the actual amount of power actually given out by the fan. The mechanical efficiency of the fan will of course depend on the type, construction, and appropriateness of the fan. It is quite evident that the choice of an efficient engine materially affects the results given by the fan; for an efficient fan when driven by a wasteful engine becomes practically on a par with a bad type of fan driven by one of the best of engines. The economy of the engine will depend on the amount of fuel consumed per horse-power per unit time. Mr. R. A. S. Redmayne, H.M. Chief Inspector of Mines, in *Modern Practice in Mining*[*] says, "In determining the comparative efficiency of fans it is necessary to take into consideration the efficiency of the motors" (steam or otherwise) "driving them. The coal consumption in pounds per horse-power should not be above 4, and even that is high. It would not be unreasonable to require of she makers a guarantee that the consumption shall not exceed 2lb. per indicated horse-power."

The indicated horse-power of a suitable fan and engine required to circulate a desired quantity of air usually varies from 1·65 to 3 times the useful effect, E, in the air. A word of warning is here necessary. The useful effect mentioned here is not meant to imply the effectiveness or efficiency of the fan, but is stated in horse-power, and means the *effective* horse-power or horse-power in the air. By indicated horse-power of a suitable fan and motor is meant the *gross* H.P. of the ventilator—the fan and its engine, or the horse-power input at motor. This includes the efficiency of motor, and gives out the brake horse-power on fan shaft. The B.H.P. on fan shaft includes the mechanical efficiency of fan, and gives out the indicated horse-power in the air. Taking an example to make this clearer, a certain test showed the I.H.P. in the air to be 321·5, whilst the B.H.P. on fan shaft (given out by motor) was found to be 390. This gave a mechanical efficiency of fan as $\frac{321{\cdot}5 \times 100}{390}$ = 82·43 per cent. The horse-power input at motor was shown as 420 horse-power (the output at motor as 390), which gave the efficiency of motor as $\frac{390 \times 100}{420}$ = 92·85 per cent.

The combined or over-all mechanical efficiency of fan and motor can then be obtained by:—

$$\text{Mechanical efficiency of ventilator} = \frac{\text{H.P. in air} \times 100}{\text{Input H.P. of motor}}$$

$$= \frac{321{\cdot}5 \times 100}{420} = 76{\cdot}55 \text{ per cent.}$$

It has been stated that the indicated horse-power of a suitable fan and engine required to circulate a desired quantity of air usually varies from 1·65 to 3 times the useful effect, E, in the air. This is where the motive power used is steam, and the actual power will depend, as indicated, on the consumption of coal per I. horse-power. It will be realised however that where an electric motor is used the efficiency of the motor is generally higher than the efficiency of the steam engine, and a less input horse-power at motor will suffice. Where steam is used, and taking the above assumption as an accurate one, then since the H.P. in the air is equal to

$$E = \frac{Q \times \text{W.G.} \times 5{\cdot}2}{33000},$$

the input horse-power at engine will vary from—

$$1{\cdot}65 \frac{Q \times \text{W.G.} \times 5{\cdot}2}{33000} = \frac{Q \times \text{W.G.} \times 5{\cdot}2}{20000} = \frac{Qwh}{20000};$$

[*] "Modern Practice in Mining," Vol. IV. The Ventilation of Mines, page 174.

$$\text{to } 3\ \frac{Q \times \text{W.G.} \times 5{\cdot}2}{33000} = \frac{Q \times \text{W.G.} \times 5{\cdot}2}{11000} = \frac{Qwh}{11000}.$$

Having now settled the question of power necessary to give the desired quantity of 300,000 cubic feet per minute, with a 6 inch W.G., and found the H.P. in the air to be 284, we can say that if steam is used, the indicated horse-power of the steam engine must be from $1{\cdot}65 \times 284 = 468{\cdot}6$ to $3 \times 284 = 852$, according to its consumption of fuel and efficiency. If an electric motor is used, coupled direct to the fan the combined mechanical efficiency of fan and motor may be about 75 per cent. (Note this combined efficiency with that named above which actually gave a combined mechanical efficiency of 76·5 per cent.) On this efficiency the input horse-power at motor to give 284 indicated horse-power in air will be

$$\frac{284 \times 100}{75} = 378{\cdot}66 \text{ horse-power input at motor.}$$

Before fitting any fan to the mine its appropriateness must be considered, for which it will be necessary to take into account the equivalent orifice of the mine, and the orifice of passage of the fan. The *equivalent orifice* of the mine is practically a measure of the resistance experienced by the air in passing through the mine, for Murgue, for purposes of comparison, likened the conditions of a mine to a square opening or orifice in a thin plate. This means that any mine ventilated by a known volume of air under a certain water-gauge or depression is the exact equivalent to an orifice in a thin plate, which allows of the passage of the same volume of air under the same water-gauge. The equivalent orifice of a mine may be found as follows :—

Let a = area of orifice in square feet;
q = quantity of air passing in cubic feet per minute;
W.G. = ventilating pressure in inches of water-gauge.

Then taking the weight of a cubic foot of air at about 0·0761b.,

$$a = \frac{\cdot 000388\, q}{\sqrt{\text{W.G.}}}.$$

Substituting the given values,

$$a = \frac{\cdot 000388 \times 300000}{\sqrt{6}} = \frac{11640}{245} = 47{\cdot}51 \text{ square feet.}$$

The Orifice of Passage.—Just as Murgue represented the resistances of a mine by the equivalent orifice, so he represented the resistance to the passage of air through a fan by another orifice, which he termed the orifice of passage of the fan. Then what the *equivalent orifice* is to the mine so is the *orifice of passage* to the fan. A ventilator, owing to its construction and possible imperfections, even while exhausting air from a mine, forms at the same time an obstacle or resistance to the passage of the air, so that if H be the initial water-gauge or depression of the fan, and h the effective depression, then the difference of H and h, which may be represented by h_1 is the water-gauge occupied in overcoming the resistance in the fan itself, and

$$h = H - h_1.$$

The orifice of passage of the fan may be represented by o. The air-current then may be considered as being induced through two orifices successively, the equivalent orifice a of the mine by the effective depression h, and the orifice of passage o of the fan by the absorbed depression h_1. Now it follows that a strict relationship exists between a and o, inasmuch that if $\frac{a}{o}$ is equal to or greater than unity, the fan is too small for the resistances of the mine. Mr. H. W. Halbaum* states that "all fans develop their maximum efficiency on equivalent orifices not less than $o/4$ and not greater than $o/2$"; and "any fan will work up to within 2 or 3 per cent. of its maximum efficiency, if the relation between the mine and the fan be such that $a = o/3$ or $o = 3a$," or in other words if the area of orifice of the fan is three times the area of the orifice of the mine. Then since $a = 47{\cdot}51$ square feet, o will equal $3 \times 47{\cdot}51 = 142{\cdot}53$ square feet.

Manometric Efficiency.—It has been said that there is a theoretical depression due to the peripheral speed of the fan, which is never realised. Some fans very favourably approach the actuality; others show only moderate attempts at reaching it. If perfection reigned in the fan the initial depression H and the theoretical depression would be the same, and $H = \frac{u^2}{g}$, where u represents the tangential velocity in feet per second of the fan; and g = gravitation unit = 32·2. But since this perfection is never realised, it becomes necessary to multiply by a fraction representing the maximum manometric efficiency of the fan. If k represents this fraction which expresses the proportion of the initial depression to the theoretical depression, then

$$H = k\frac{u^2}{g}.$$

$$\text{and } u = \sqrt{\frac{Hg}{k}}$$

in which H represents initial depression in feet of motive column.

The speed per second of the rim of the fan, *i.e.*, the tangential velocity in feet per second, U, required to produce a given quantity Q, and water-gauge h inches may be determined by the formula :—

$$U = \frac{Q}{40}\sqrt{\frac{a^2 + o^2}{2k \times a^2 \times o^2}}.$$

The value of k may be taken as ·5 for Schiele fan, ·6 for Waddle fan, and ·7 for Guibal fan; the Walker, Rateau, and Sirocco have values of k from ·7 to ·9. Now assuming our manometric efficiency, k, as ·7, and substituting values,

$$U = \frac{300000}{40}\sqrt{\frac{47{\cdot}5^2 + 142{\cdot}5^2}{2 \times {\cdot}7 \times 47{\cdot}5^2 \times 142{\cdot}5^2}}.$$

$$U = 7500\sqrt{\frac{2256{\cdot}25 + 20306{\cdot}25}{1{\cdot}4 \times 2256{\cdot}25 \times 20306{\cdot}25}}$$

$$= 7500\sqrt{\frac{22562{\cdot}5}{1{\cdot}4 \times 2256{\cdot}25 \times 20306{\cdot}25}}$$

$$= 7500\sqrt{\frac{10}{1{\cdot}4 \times 20306{\cdot}25}}$$

$$= 7500\ \frac{3{\cdot}163}{1{\cdot}183 \times 142{\cdot}5}$$

$= 140$ feet per second, or $140 \times 60 = 8{,}400$ feet per minute.

Another rule which has been shown as $u = \sqrt{\frac{Hg}{k}}$ is simpler in calculation, but gives a little higher result than the above. Working through this we get, where H may be taken as $\frac{10}{9}h$, and assuming that 1 inch of water-gauge represents 68 feet of air column, then

$$u = \sqrt{\frac{408 \times 10 \times 32{\cdot}2}{9 \times {\cdot}7}}.$$

$u = 144$ feet per second, or 8,640 feet per minute.

Suppose it is decided to adopt a slow running fan of large diameter, say the Guibal type. A 36 feet diameter fan would then require to make

$$\frac{8400}{36 \times 3{\cdot}1416} = \text{say 75 revolutions per minute.}$$

Or the fan may be a Waddle of the same size, both fans being within good range. A small quick-running fan, say of the Sirocco type, could be obtained to give the result when such fan could be coupled direct to motor. The fans suitable then are the Guibal, Waddle, Walker, Schiele, Capell, Sirocco,

* "An Extension of the Equivalent Orifice Theory," by Mr. H. W. Halbaum. Trans. Inst. Mining Engineers. Vol. XXI., page 366.

&c. Walker fans are at work passing quantities up to 500,000 cubic feet per minute, and creating effective depressions up to 10 inches of W.G. One Walker fan near Wigan passes a volume of 500,000 cubic feet per minute with a 6 inch W.G.; the fan diameter is 30 feet, and the width 9 feet.

To find the diameter of the cylinders of the engine for driving fans, the following rule is given by Mr. R. A. S. Redmayne, Chief Inspector of Mines, in *Modern Practice in Mining*:—

If D = the diameter of the cylinders;
Q = the quantity of air in cubic feet per minute;
P = the power necessary to drive the fan;
h = the height of the water-gauge in inches.

Then
$$D = \frac{Q \times h}{\cdot 7854 \times P \times 250 \times g},$$

from which for steam driven fans it is easy to calculate the size of engines necessary.

Summary.—To give 300,000 cubic feet of air per minute, we might employ a Guibal fan, direct-driven by a single-cylinder horizontal engine, in which the diameter and stroke of engine is, say 30 inches. Diameter of fan, 36 feet, with diameter of inlet, 14 feet; width at inlet and width at periphery, say 12 feet each. Or a Walker fan running, say at same power, but having a diameter of 30 feet.

If a small fan is preferred, the following will give an idea of the build and calculation. "Sirocco fan, double inlet type, 11 feet 8 inches in diameter, coupled direct to a three-phase motor:—*

Speed of fan and motor, 183 r.p.m.
W.G. in fan drift, 6 inches.
W.G. in main drift, 6 inches.
Average velocity of air, 1,842 feet per minute.
Area of drift, 184·6 square feet.
Volume of air, 340,033 cubic feet per minute.
H.P. input at motor, 420 H.P.
Efficiency of motor, 93 per cent.
B.H.P. on fan shaft, 390.
I.H.P. in air, 321·5.
Mechanical efficiency of fan, 82·43 per cent.
Combined mechanical efficiency of fan and motor, 76·6 per cent."

DANGERS OF COAL DUST IN MINES.

Discussing the Best Methods to be Adopted to Reduce or Remove those Dangers.

By KING'S MEDALLIST.

The history of coal mining in the United Kingdom during the latter half of the 19th century is a very sorry record, and the tale of human lives lost by *explosions alone* during that period is a doleful one. During the 50 years, 1851 to 1900, the number of lives lost from this cause amounted to 10,089, giving a yearly average of over 201. Midway in the period, viz., in 1873, the first really effective Coal Mines Regulation Act came into force. Scientific and mechanical means were employed to improve the working and ventilation of the mines; the regulations of the Act were more stringently enforced by a larger staff of inspectors, and the use of safety-lamps was made compulsory in many collieries. Despite all this, disastrous explosions were frequent in occurrence. In the eight years ending 1880, 1,763 lives were lost by greater explosions, and 500 by lesser ones, the specific years, 1875–77–78–80, being very heavily marked. It is a sad reflection that during the first decade of the 20th century the record is a dismal one.

Previous to 1880 these disasters had always been attributed to "explosions of fire-damp," and CH_4 was believed to be the sole cause of them. Various theories were formulated as to the reason why these catastrophes happened in some of the best ventilated mines in the country, even where the existence of gas was extremely rare, or at least unsuspected, and the puzzle was how to account for the sudden appearance of gas in quantity sufficient to cause such tremendous results. One of the reasons given during the first half of the century was that the workings were for the most part on the "bord and pillar" system, and that the goaves thus became huge reservoirs of gas. When a fall of roof happened there was a probability of some of the gas being dislodged, which finding its way into the workings might be accidentally ignited.

This theory was abandoned when it was proved that most of the great explosions occurred in mines where there were no goaves, and so the theory of "outburst of gas" was put forward and up to about 25 years ago this was the almost universal opinion. Some cause must have existed for the explosion, and what more ready explanation was there than the supposition of a sudden outburst of gas at a critical moment, such as the firing of shots on the face or in the ripping? In furtherance of this view it had been noticed that sometimes explosions had happened coincident with shot-firing, and the natural conclusion was that the shot had liberated the gas in so large a volume as to account for the extent of the disaster. This led to greater precautions in the use of explosives and safety-lamps; the prohibition of miners carrying matches, and smoking in mines; in fact every large colliery was treated as if it were a gasometer full of gas, ready to explode at any moment.

But during all this time it is certain that in some minds there was some idea that *coal dust* played a part in these disasters. The first mention of this was in 1803 or 1804. Again in 1812 in a description of the "Felling" explosion, the Rev. J. Hodgson stated that "great quantities of coal dust were ejected from the shafts." In 1845 Messrs. Lyell and Faraday, in connection with an explosion at "Haswell" Colliery in 1844, said, "in considering the extent of the fire for the moment of the explosion, it is not to be supposed that fire-damp is its only fuel; the *coal dust* swept by the rush of wind and flame from the floor, roof, and walls of the workings would instantly take fire and burn, if there were oxygen in the air present to support combustion"; and further "that there is every reason to believe that much coal-gas was made from this dust in the very air itself of the mine by the flame of the fire-damp which raised and swept it along." At an inquest in 1855 an unknown witness made a remark tending to the same fact. Later on Messrs. Atkinson wrote a pamphlet on the connection of *Coal dust and Colliery Explosions.* Notwithstanding these records it would appear that by most people the existence of *coal dust* in mines constituting an element of danger, had been discounted, and the idea that it was a potent factor at all in colliery explosions seems to have been almost ignored in this country. On the other side of the English Channel, however, references to the subject are plentiful; as far back as 1855 and afterwards in 1864—1872, and 1874. French experts spoke out plainly and clearly as to the part *coal dust* had played in various explosions in French collieries. Particularly a statement by M. Siebel in 1874 is worth quoting in extenso, because it so clearly points out the real danger of *coal dust.* "The absence of fire-damp having been well verified, we believe that in order to explain the accident it is necessary to admit the combustion of *coal dust* raised by the explosion of the shot." In 1875 M. Vital, after experimenting with coal dust in a laboratory apparatus, came to the conclusion that "very fine *coal dust* is a cause of danger in dry workings in which blasting is practised; in well ventilated workings it may of itself alone give rise to disasters; in fiery workings it increases the chances of explosions, and when accidents of this kind do occur it aggravates their consequences."

The dangers arising from *coal dust* in mines are, as briefly summarised by Royal Commission, 1891—1904:—

1.—The danger of explosion in a mine in which gas exists, even in very small quantities, is greatly increased by the presence of *coal dust.*

2.—A gas explosion in a fiery mine may be intensified and carried on indefinitely by *coal dust* raised by the explosion itself.

3.—*Coal dust* alone, without the presence of any gas at all, may cause a dangerous explosion if ignited by a blown-out shot or other violent inflammation. In this case, however, the conditions must be exceptional, and only on rare occasions likely to be present.

4.—Whilst different dusts are inflammable and consequently dangerous, it cannot be said with certainty that any dust is quite free from risk.

* Colliery Managers' Pocket Book.

While there does not appear to be any great probability that a dangerous explosion of *coal dust* alone could be produced in a mine by a naked light or any ordinary flame, yet it is well known that such an explosion has actually occurred under a screen on the surface.

In addition to the enormous loss of human life which of course is the one to be most deplored, there is the tremendous amount of damage done to the workings and to the plant, oftentimes fires are caused which add to the difficulty of recovery of the mine, to say nothing of the enormous expense which these disasters entail.

I may, by way of summing up the dangers of coal dust, here note the statement of H.M. Chief Inspector of Mines (R. A. S. Redmayne), in regard to the West Stanley explosion in 1909, and again repeated in connection with the Whitehaven disaster in 1910. "That unless the grave danger which exists at many collieries owing to the presence of *coal dust* is attacked with much greater earnestness in the future than it has been in the past, great disasters of a similar character will occur from time to time."

Within eight months of this latter disaster the prediction was verified at Hulton Colliery, and the verdict of the Coroner's jury recorded "that from an accidental ignition of gas and *coal dust* there followed a large ignition and *explosion* of *coal dust*, affecting the whole of the workings of the pit."

The dangers of *coal dust* in mines being practically admitted on all sides, the question of the reduction or removal of those dangers is one which must be seriously considered by mining experts and officials.

Now as to finding a remedy for the evil. At a meeting held at Manchester some months ago the very pertinent question was asked, "Why not, instead of treating it, stop an explosion at its source?" Sir Henry Hall has stated in very plain words that "to arrest an explosion after it had travelled a considerable distance was a most difficult matter." All experiments tended to confirm that statement, therefore my idea is that if all possible means are taken to avoid the initial stage of the explosion, and I contend that there are practical means to this end, then we shall have much less to be sorry for, in the way of big disasters. Prevention, to my mind, is better than cure in this case as in many others; why not take the measures to prevent the accumulation of coal dust? All the "dangerous" dust along the roads is practically *coal dust*, and I think this accumulation may be to a great extent prevented, especially along the main haulage roads of our mines, by one or more of the following methods:—

1.—By the provision of good rolling stock—the tubs being constructed of iron or steel, which would prevent the fine particles of coal from dribbling through in transit from face to shaft; wood-bodied tubs allow of this to a great extent.

2.—By covering the tub and contents with a sheet of some kind, preferably damped; this would prevent the fine dust which naturally rises from the coal in travelling being carried along by the air-current and subsequently scattered along the road. In September, 1907, in a haulage road at the Middleton Colliery, a snuff from an oil lamp wick was seen to ignite the dust rising from a train of tubs drawn by a horse. The flame travelled for some distance against the air-current, then turned back again with it, dying out quietly.

3.—By a method of spraying or drenching the loaded tubs before, or as soon as, they are clear of the coal-face. I am, however, quite aware that it would not do to serve all coal in that way for many reasons.

In order to deal with the *coal dust* generally, so as to secure immunity from the danger which admittedly exists, many methods have at one time or other been put forward, including the following:—

(*a*) Cleaning up and loading up the dust along the roads from floor, roof, sides and timber. The use of a vacuum apparatus has been suggested for this purpose, but it does not seem to be practised to any great extent as it is stated to be ineffective.

(*b*) Application of calcium chloride and other salts which liquefy in the air and render the dust moist. The use of a soap solution for spraying has been recently suggested. It is said to have the effect of coating the dust with a solid crust, which although very thin, prevents the raising of a "dust cloud."

(*c*) Humidifying the intake air-current by steam sprays so that moisture might be conveyed to the dust as the current travels; 8 to 10 per cent. is said to be sufficient for the purpose. An objection to this course is the creation of "fog" in the insets and approaches and along the haulage roads near to the pit-eye.

(*d*) Sprinkling by water cars; provision of pipe-lines with permanent sprinklers, or using hose and nozzles or sprayers for washing down. I do not think that this course will commend itself to many managers on account of the risk of damage to roof, floor, and sides of main roads.

As to *b*, *c*, and *d*, these methods would have the effect of making the dust inactive, but on the principle of prevention *versus* cure, methods designed for the limitation of the "initial" explosion might be:—

(*e*) The more stringent use of permitted explosives, and then only after compliance with existing regulations.

(*f*) The construction of brick or concrete linings of definite length and placed at suitable points, which could and should be kept perfectly clean at all times, as well as continually wet, might be of advantage in limiting the extent of explosions by confining their effect to smaller areas. The explosion at Courriéres was arrested at one point by a device of this character.

(*g*) The provision of dustless zones has been suggested, but from the results of experiments noted in the British record, it is said that they had proved ineffectual in extinguishing the flame due to the ignition of a *coal dust* zone of 275 feet. The dustless zone, it was found, could not be maintained because the "pioneering cloud" carried forward the fine dust in advance of the flame.

There is one other remedy or rather antidote, which on the authority of Mr. Garforth, appears to be effective, viz., the spreading of "*stone dust*" along the roads, where *coal dust* exists, systematically and thoroughly. He quotes from the British record, and shows that the flame due to the ignition of a *coal dust* zone of 275 feet which usually extended 140 to 180 feet, had been extinguished by a *stone dusted* zone in 55 feet and 54 feet, and in one particular instance the flame was put out in the short length of 22 feet. Chemical analysis showed that the *stone dust* produced a cooling effect on the incandescent portions of an explosive blast, acting in a similar manner to the safety lamp in regard to inflammable gas. Microscopic examination of the dust collected after the explosion at Altofts—Silkstone, and also after the experiment, showed that the fine stone dust had adhered to minute particles of tarry and pitchy coal.

Further than that, the mechanical effect of the explosion was lessened to a great extent; with the explosion of a definite quantity of *coal dust minus stone dust* a pressure of 112lb. to the square inch was developed, whilst with the same quantity of *coal dust plus stone dust* the pressure recorded fell to 33lb. to the square inch.

Care must, however, be taken that the *stone dust* is non-silicious in character on account of the danger of causing "miners' phthisis." If the stone dust is aluminous in character it is harmless in that respect. The cost of grinding and spreading the stone dust is very slight, being on Mr. Garforth's evidence, well under $\frac{1}{8}$ of a penny per ton of output. The quantity of *stone dust* he is applying is $1\frac{1}{2}$ cwts. per yard of roadway, and assuming that the *coal dust* averages 10lb. per yard, the proportion works out at 17 of *stone dust* to 1 of *coal dust*, or in other words, the proportion of *coal dust* is $5\frac{1}{2}$ per cent. in the mixture.

As a result of his experience in the recovery of the Altofts pit and the impression produced on his mind by what he saw, during the three months of exploration work connected therewith, of the action of *stone dust* on an explosive blast, Mr. Garforth tells us that the experiments at Altofts recently made were carried on in imitation of that disaster; and that he is convinced that until a *better remedy or preventive* against the danger of *coal dust* can be discovered, *stone dust* should be used wherever *coal dust* is found to exist.

In the meantime every encouragement ought to be given to investigators working out the problem on scientific lines. In the conclusions arrived at by British, French, Austrian and American experts from experiments made more or less simultaneously during the past few years, we find very little difference of opinion, and from their further labours we may expect good results. In conclusion I think we may hope that we are almost within hand-reach of a satisfactory solution of the great and important question or problem of *coal dust and its dangers.*

CORRESPONDENCE.

Correspondence is invited upon all matters affecting coal and metal mining and the kindred industries. The Editor cannot be held responsible for the opinions expressed nor for the accuracy of the information. It is important that correspondents should observe the following rules:—(1) To write only on one side of the paper. (2) To submit sketches, if any, on unruled paper, separate from the MSS., and in Indian Ink. (3) To write plainly, especially all proper names. (4) To write with brevity and point. (5) To avoid personalities. (6) To enclose with letters intended to be published anonymously their names and addresses as evidence of good faith. (7) Correspondents who desire to preserve their letters should keep copies, as the Editor cannot undertake to return rejected communications.

Mines Act.

To the Editor of The Science and Art of Mining.

Sir,—Kindly insert the following in your valuable paper:—

May I suggest that proper means of raising men on all drifts should have been compulsory and included in the new Mines Act? There are gradients which men are walking day after day up to 27 and even 28 inches to the yard, after a hard day's work. Surely something ought to be done to safeguard the health of the men as well as the mine.

Yours, &c., P. N. V.

Information Wanted.

To the Editor of The Science and Art of Mining.

Sir,—I should like Tyke or any reader to answer me the following question for the benefit of many readers in this district:—

Can 1½ per cent. of gas, CH_4, be detected on a flame of a Marsaut, or Mueseler safety-lamp? I myself have seen and have read many authorities that it takes a person skilled in gas-testing to detect the presence of 2½ per cent. to 3 per cent. of CH_4.

I should like to have this question answered as soon as you can make space enough in your valuable Journal, as it is a question much discussed at the present time.

Yours, &c., One of Your Readers.

The Theory of the Fan.

To the Editor of The Science and Art of Mining.

Sir,—In calculating the water-gauge of a fan should we use the formula $H = \frac{V^2}{2g}$ or $H = \frac{V^2}{g}$, where H = ventilating pressure in height of air column, V = velocity in feet per second of vane tips, and g = accelerative effect due to gravity?

My answer to that question is $H = \frac{V^2}{g}$ is the correct one to use.

I will first show how the formulæ in connection with falling bodies are obtained.

Suppose a body falls from rest:

Its velocity on starting is 0 feet per second.

Its velocity at the end of 1st second is g feet.

Its velocity at the end of 2nd second is $2g$.

Its velocity at the end of t seconds is tg.

Let $tg = v$. Then $t^2g^2 = v^2$.

Average velocity = ½ (initial velocity + final velocity) = ½ $(0 + tg)$ = ½tg.

Distance fallen = time × average velocity = $t \times \frac{1}{2}tg = \frac{1}{2}t^2g$.

Let $H = \frac{1}{2}t^2g$.

Multiplying both sides by $2g$ we get $2gH = t^2g^2 = V^2$, then $H = \frac{V^2}{2g}$ and $2H = \frac{V^2}{g}$.

$2H = \frac{V^2}{g}$, also $V^2 = 2gH$ $V = \sqrt{2gH}$. (2).

I will now show that water falling from a height H can balance a column of water $2H$ feet in height in a J tube with its lower mouth under the water-fall.

If a cubic foot of water weighs 62½lb. the pressure per square foot at the bottom of a column of water $2H$ feet high will be $2H \times 62\frac{1}{2}$lb. Let the cross-section of the falling water be 1 square foot, and its velocity be V when it impinges on the lower mouth of the J tube.

Weight of water falling per second = $1 \times V \times 62\frac{1}{2}$.

Momentum = mass × acceleration.

Momentum of falling water = $V \times V \times 62\frac{1}{2}$.

But $V = \sqrt{2g}$ feet. (2)

Putting in this value we get—

Momentum of falling water = $\sqrt{2gH} \times \sqrt{2gH} \times 62\frac{1}{2}$.

Momentum of falling water = $2gH \times 62\frac{1}{2}$ poundals.

Momentum of falling water = $\frac{2gH \times 62\frac{1}{2}}{g}$lb.

Momentum of falling water = $2H \times 62\frac{1}{2}$lb.

But this is the pressure due to a column of water $2H$ or $\frac{V^2}{g}$ feet high and 1 square foot in cross-section, therefore water falling a height H can balance a column of water twice the height in a J tube with its lower mouth under the water-fall. If it were possible to give the falling water this impulsive pressure at the point where the water begins to fall from rest the same results would be obtained—the impulsive pressure would support a column of water $\frac{V^2}{g}$ feet in height.

In the same way it can be shown that the blades of a fan moving at a velocity of V feet per second can support an additional column of air $\frac{V^2}{g}$ feet in height, therefore the air column producing ventilation is not $\frac{V^2}{2g}$ but $\frac{V^2}{g}$.

The same result is also reached in this way:—

Let V = velocity of vane tips in feet per second. Then the change in tangential velocity of the air = V, being zero at the inner part of the vane, and V at the outer.

Let M = mass of air in lb. discharged per second.

Change of tangential momentum = MV.

Force which vanes have to exert = $\frac{MV}{g}$lb.

This force may be imagined to be concentrated at the rim of the fan, so that work done per second by fan = $\frac{MV}{g} \times V$, for work = force × distance.

Work done per second = $\frac{MV^2}{g}$.

But what is the meaning of this formula? Suppose the air of the same density throughout. Fancy yourself seated on the upper surface of our atmosphere 5 miles high, looking down on a colliery fan which is being repaired. As long as the fan is at rest the upper surface of the atmosphere extends in all directions around you a level plain without a single height or hollow. But now the fan begins to move; the blades heave up a column of air of a certain sectional area. It continues to rise until the top of it stands $\frac{V^2}{g}$ feet above the level of the plain on which you are seated, the projecting part weighing Mlb.

To illustrate what I have been speaking about I will work out the following problem:—

A fan 28 feet in diameter makes 120 revolutions per minute. Find the water-gauge it will have.

Diameter = 28 feet.

Circumference = $\frac{22}{7} \times 28$ feet = 88 feet.

Velocity per minute = 120 × 88 feet = 10,560 feet.

Velocity per second $\frac{10560}{60} = 176$.

Air column = $\frac{V^2}{g} = \frac{176 \times 176}{32} = 968$ feet.

Air column = 11,616 inches, but as water is 800 times heavier than air, this is equivalent to $\frac{11616}{800} = 14{\cdot}52$ inches of water.

Water-gauge = 14·52 inches.

This would be the water-gauge produced by a perfect fan 28 feet diameter, making 120 revolutions per minute when the downcast shaft was completely closed, so that no air could pass through the fan.

Yours, &c., W. Grieve.

NOTES FROM WALES.

By BRYCHAN.

QUESTIONS SET AT THE EXAMINATION FOR MANAGERS' FIRST CLASS CERTIFICATES OF COMPETENCY, SOUTH WALES MINING DISTRICT, MAY, 1912.

GEOLOGY.

1.—Describe the use of Geology to the mining engineer.

2.—What is meant by specific gravity? How is the specific gravity of coal ascertained?

3.—State the modern views on the origin of anthracite of the South Wales Coalfield.

4.—What are the positions of the Old Red and the New Red Sandstones in relation to the Carboniferous system? Although the name New Red Sandstone is still largely retained, how are these rocks now named?

Maximum Marks, 10.

MACHINERY.

1.—State the advantages of heating the boiler feed water, and describe how it is done.

2.—State the relative merits of three-phase and continuous current for colliery purposes.

3.—Give sketches of a bucket pump and a plunger pump, and describe the action of each.

4.—What are the precautions to be taken to avoid accidents in connection with the running of electric installations in collieries?

Maximum Marks, 40.

VENTILATION.

1.—Describe four of the instruments or appliances best known to you for the detection of inflammable gas in a fiery mine. State how you would proceed to use one of them in an ordinary examination at a mine under your charge.

2.—A mine is very fiery and dry and dusty. It employs 1,374 men and boys, and there is an average output of 1,408 tons per day. There are 84 horses. The main roads extend to considerable distances from the pit, the nearest working place being at 1,100 yards. The ventilating current is 240,000 cubic feet per minute, distributed in five splits, varying from 28,000 to 60,000 feet each. In order to ensure a maximum of safety explain what precautions you would take for efficient examination of the ventilating currents, both as regards quantity of gas and the prevention of coal dust.

N.B.—The candidate must not quote the requirements of the Mines Act, but simply state what methods *he* would adopt in his daily management and control of the mine.

3.—Make a full size drawing (half section, half elevation) of the safety-lamp you use in your daily occupation, and supply particulars and a description of the parts. Explain the principles that are brought to bear in its use, and state the circumstances under which the lamp may become unsafe.

4.—A main return air-way exists in a seam of coal whose roof has hitherto been considered exceptionally strong. Its dimensions are 11 feet wide by 8½ feet high, and there is a current of 172,000 cubic feet per minute passing through it. A layer of roof 3 feet 2 inches thick has fallen over a distance of 134 yards, and rests on the floor until arrangements are made for its removal. What is your opinion as to its effect upon the present ventilation—

(*a*) as to velocity;
(*b*) as to volume;
(*c*) as to "drag";
(*d*) as to horse-power?

Say whether either of these will be affected, and to what extent. Give details of any computation you may make.

Maximum Marks, 40.

SURVEYING.

1.—A seam of coal has been proved by a pit 100 yards deep, and won by a declivity drift driven through the measures for a distance of 532 yards at a dip of 24° 15′, and in a direction N4°E. Its mouth is at 874 links N73°W from the centre of the pit. From the bottom of the pit the following drivages have been made in the coal:—

(1) 240 links N89°20′E rising 7½°.
(2) 273 links N34°30′E rising 12¼°.
(3) 434 links S80°30′E rising 5°.

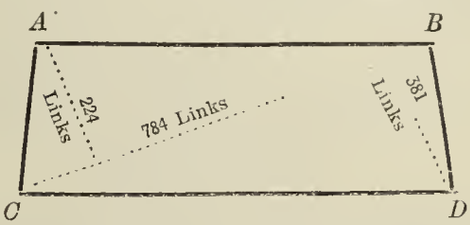
From this point it is intended to drive a straight road of uniform dip out to the pit bottom, working both ends—

(*a*) what will be its direction;
(*b*) and inclination or dip?

2.—Describe how you would conduct a theodolite survey to arrive at the information required in the above question. Give a copy of your survey notes of same, and state what methods you would adopt to ensure accuracy in giving the bearing for drivage at each end.

3.—What is meant by a scale of $\frac{1}{2500}$?

4.—A rectangular plot of coal is of the following dimensions:—



The level course is from *C* to *D*, and the dip is 27½°. What is the quantity of coal in a seam 4 feet 7 inches thick, assuming the weight to be 19 cwt. to the cubic yard?

Maximum Marks, 20.

WORKING COAL.

1.—What average output per day in tons would you expect from each yard of long wall face with a seam 7 feet 6 inches thick, the roof of the seam being what is usually found in a steam coal colliery in South Wales?

2.—How many tons of coal on an average per day can be expected to be hauled by each underground horse? State how you make the calculation.

3.—State fully how you can reduce the ordinary cost of pit timber in a steam coal colliery. Safety to the workman must be the principal factor in considering your answer.

4.—Do you consider the Mines Eight Hours Act has tended to reduce accidents? Also give details of your own experience of the working of the Act—

(1) as to output;
(2) as to efficiency.

Maximum Marks, 40.

MINES ACTS.

1.—State the principal rules in regard to the employment of electricity.

2.—Give the rules as to the use of steam boilers.

3.—Describe what rules are necessary for the inspection of machinery.

4.—What are the regulations necessary in the use of explosives?

Maximum Marks, 20.

ARITHMETIC.

1.—Required the length of an arc of 60°, the radius of the circle being 14 feet.

2.— Reduce 8s. 4½d. to the decimal of £1.
(*b*) Divide 88 by ·88.
(*c*) Subtract $\frac{4}{7}$ from $\frac{15}{5}$.

3.—A cylindrical vessel 3 feet deep is required that shall contain twice as much as another cylindrical vessel whose diameter is 3½ feet, and altitude 5 feet; find the diameter of the required vessel.

4.—A mass of lead ore weighed 7 tons; one portion of it yielded lead 78 per cent., and silver 8 ounces per ton. The remaining portion yielded lead 75 per cent., and silver 7½ ounces per ton. The total yield of silver was 55 ounces. What average percentage of lead did the whole mass contain?

Maximum Marks, 20.

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Testing for Gas—Ventilation—Shot-Firing—Geology—Coal Dust—Mechanics (illus.)—Boring—Sinking—Pumping (illus.)—Winding Engines (illus.)—Self-Acting Tipplers (illus.).. ...590-600
Otter Hounds Imprisoned in a Drift 600
New Coal Seam in Cumberland 600
Watering Roadways 600

The Science & Art of Mining.

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ESTABLISHED 1890.

WIGAN, SATURDAY, JULY 20, 1912.

YORKSHIRE COLLIERY DISASTER.

At the very time when the King and Queen were starting on their industrial tour throughout the West Riding of Yorkshire, and almost at the moment when they were beginning to gain an insight into the working of the great colliery industry, the whole country was shocked by the news of a dreadful explosion. At the Cadeby Main pit of the Denaby and Cadeby Colliery Company, Conisborough, early on Tuesday morning 9th inst., one of those calamities occurred which ever and anon overtake the mining world, despite the utmost precautions that science and care can devise.

The only consoling feature about the terrible affair is associated with the visit of their Majesties, as, but for the visit, it is highly probable that the loss of life would have been much greater. Situate in the heart of the district visited by the King and Queen, it was only natural that the Cadeby men should make holiday, and, owing to this fact, there were only thirty-seven men, instead of the usual 136, working in the underground district where the explosion occurred. Altogether, there were 500 men in the pit at the time of the first explosion. Of the thirty-seven working in the district affected, only two escaped.

The news of the disaster was sent to Wentworth, and the King and Queen were at once supplied with all the details available. Their Majesties immediately sent, through Lord Stamfordham, the following telegram to Mr. W. H. Chambers, managing director of the colliery company :—

"The King and Queen are shocked to hear of the terrible accident at your colliery. The fact that their Majesties were near to the scene in the midst of so much rejoicing when they visited Conisborough yesterday brings home to them still more the sorrow and sadness which now prevail amongst you.

"I am desired to express their Majesties' heartfelt sympathy with the families of those who have perished and with the sufferers in this grievous calamity."

There were two explosions early in the morning, and others during the afternoon, and it was one of the latter which added most to the death-roll, carrying away a numbr of brave rescuers who had descended the pit in the hope of rendering aid to any who might be still alive. The disaster took place in the south-west portion of the mine, the first explosion being about one o'clock, and the second, which was more terrific, at five o'clock. So great was the noise of the second explosion that it was heard two miles away. Fire in the mine followed the explosions. The cause is supposed to have been the ignition of gas by a gob-fire, but this was not then definitely established.

There were agonising scenes on the pit bank throughout the day. From an early hour a crowd of people, composed chiefly of women and children, gathered and waited patiently for news, hoping against hope that the reports exaggerated the effects of the disaster. Their worst fears were realised later.

Among the killed were three Government inspectors, Mr. W. H. Pickering, chief inspector, Mr. Hewitt, of Sheffield, and Mr. Tickle, of Doncaster. Mr. W. H. Pickering was a native of the Wigan district. He was born at Harvey House, Gathurst, his father being Mr. James Pickering, who was for a long period connected with Pemberton Collieries.

Whilst a rescue party were exploring the workings early on Wednesday morning (July 10th) another explosion took place, and the gallant band had a narrow escape of sharing the same fate as the one under the late Mr. Pickering.

One man was seriously injured, and was taken to hospital, but the others, although they suffered for a time from the on-rushing gas, were able to proceed with their labours.

During the day the work of sealing up the affected area was commenced. This was found necessary in order to "kill" the fire.

On the motion for the adjournment of the House of Commons on Thursday (11th inst.), the Home Secretary (Mr. McKenna), in reply to Mr. W. E. Harvey, said he had no later information with regard to the explosion at the Cadeby Colliery, except that the number of casualties was now 86. After consultation with his advisers he had come to the conclusion that a full inquiry by an expert committee into the whole question of the circumstances in which spontaneous combustion of coal occurred, its causes, and the means of preventing it, or of dealing with it when it had arisen, would be desirable. He proposed to re-appoint such a Committee at an early date.

The inquiry into the death of three men killed by an explosion on July 6th at the Barnsley Main Colliery was resumed at Barnsley on Thursday (11th inst.) The investigation on behalf of the Home Office had been in charge of the late Mr. W. H. Pickering, and the Coroner (Mr. R. P. Maitland) addressing the Court at the outset of the proceedings, was deeply moved in referring to the deaths of Mr. Pickering and Mr. Tickle, and twice broke down completely.

Mr. Maitland said: "Since we were here last Monday, I have lost some of my dearest friends—Mr. Pickering, who sat beside me here last Monday, full of energy and life, and now he, Mr. Tickle, and poor Mr. Hewitt are gone. They were three of a band of heroes. The country has lost in Mr. Pickering one of its best and most faithful servants, and in the deaths of Mr. Tickle and Mr. Hewitt the loss has been greatly increased. I really loved Mr. Pickering as a brother; we have been very great friends. The whole affair has cast a very dark shadow over us. We are here to-day to investigate a serious case, and it seems to have been made heavier by the deplorable disaster at Cadeby. I am sure we shall sympathise with Mrs. Pickering and the relatives of not only the mines inspectors, but of the others who lost their lives."

Mr. Joseph Hewitt, solicitor, Barnsley, representing the Barnsley Main Colliery, desired to be associated with the feelings expressed by the Coroner. Mr. Pickering was a straight man, who could be trusted to deal properly and honourably with all things put before him. The nation had lost valuable inspectors.

Mr. W. E. Raley, solicitor, and the foreman of the jury (Mr. Wheelhouse) also spoke of the deep regret felt at the loss of Mr. Pickering and his colleagues.

Mr. J. R. R. Wilson, Inspector of Mines (who spoke with deep feeling) said that to him Mr. Pickering was a brother. It was by the merest accident that he (Mr. Wilson) was not with Mr. Pickering in the Cadeby Pit. "He was trying to get me," added Mr. Wilson, "on the telephone from 6 30 a.m. to 7 20, and failed, and that delay explains why I did not join him. When I got to Cadeby Mr. Hudspeth and I went down. We had got half-way down the engine plane when the second explosion came. From the force of that I realised what it meant to any one beyond me at the time. I understand, if I have never understood it before, the meaning of the expression of carrying life in your hands. You cannot understand the horror of it. When we got to the bottom of the engine plane we found a huge fall, which entirely blocked the whole roadway, and we seemed to be absolutely helpless. Ultimately, we found a little hole, and Mr. Hudspeth crept through, and I followed. We saw a most gruesome sight. Fortunately a few of the men were alive,

and we gave them a drink of water. There were heaps of dead —22 in one place. Of course I haven't got over it yet, and it will take a long time. I cannot contain myself when I think of it, and my mind has been horribly mixed up for the last day or two. I should like to say publicly that in the death of Mr. Pickering especially the country has lost one of its most capable servants, and I very much regret the death of the other inspectors —Mr. Hewitt—who had done excellent work for the country, and Mr. Tickle, whose life was so full of promise."

The Archbishop of York preached to crowded congregations at Conisborough and Denaby on Sunday sermons on the Cadeby Pit disaster. He said it was strange but true that it needed dark days to let them see the light of true nobility in human life. Suddenly in the midst of ordinary people, full of their own faults and sins and weaknesses, there came the cry that men were in danger, and the lighs of human heroism shone forth at once, and they were transformed. What came home to him was the fact that they were just the most ordinary men, and yet in the darkness of a great danger the light of something noble shone through them. God would honour them. The late Mr. Pickering used to say that if they wanted to know the best of the miner they must know him at a time of danger to his fellows. They had seen during the last few days God's own manhood, what God meant all women and men of that place to be. The preacher urged them not to let the manhood and womanhood that had shown itself capable of rising to things so great fall again to bad habits, carelessness, indifference, and passion. Continuing, he said their Majesties had told him over and over again how profoundly moved they were that they should have been there at that time. They came to Yorkshire to enter into the lives of the people, and found they were called to enter into their sorrow. He was sure all appreciated the strength of the sympathy which, in spite of their tiredness, led their Majesties to say on Tuesday evening: "We cannot rest until we have been to the people at the Denaby and Cadeby pits." Did not that cause them to feel when they heard the old State prayers that morning that they could pray for the King and Queen as they had never done before?

EXAMINATION RESULTS.

The following is a list, communicated by the Home Office, of the successful candidates at the Examination held in the South Wales District on the 21st, 22nd, 23rd and 24th May, 1912, to whom Certificates of Competency as Managers or Under-Managers of Mines have been granted under the Coal Mines Regulation Act, 1887:—

First Class (*Managers*):—Frederick Charles Baker, John Barrie, Robert James Bennett, Henry Lynch Blosse, John Addison Bosher, William Bowen, William Maurice Brownlie Burnyeat, Godfrey Claud Carter, John Christopher, Frederick Bernard Clark, David Daniel, David John Daniel, Alfred John Davies, Daniel Davies, David Davies (Cymmer), David Davies (Cwmaman), Edward Davies, Emrys Davies, Job Davies, John Davies, John Henry Davies, Thomas Llewellyn Davies, William Davies, William James Davies, Graham George Deer, Thomas Reginald Dowdeswell, Edgar David Dyer, Edwin Embrey, Daniel Evans, Henry Evans, John Evans, John Lewis Evans, William Charles Evans, Arthur Benjamin Frowen, Edward John Gay, Owen Llewellyn Gibbon, Douglas Alfred Hann, William John Harris, Charles Wyndham Hayes, William Herbert, Joshua Hopkins, James Oliver Howells, Clifford Edward Hughes, David Hughes, John James Hughes, Norman Hutchinson, Cecil Douglas James, Edmund David James, George Harry Benson James, Hugh John James, William James, David Jeffreys, Herbert Hammond Johnson, Benjamin Jones (Blaina), Benjamin Jones (Cwmaman), William James Jones, Isaac Wannop Lamonby, Anthony Lewis, Lewis Lewis, Matthew Lewis, William Morgan Llewellyn, Robert Nicholas Lundie, Albert Lyon, Herbert George Madley, William Manley, Joseph King Martin, William Francis Dewton, Thomas Edward Moody, Ezra Morgan, William Morgan, William Arthur Morgan, Thomas Morris, William John Oliver, James Parkinson, Robert Liston Partridge, Cornelius Philpott, John Powell, David John Price, John Pugh, Simeon Radford, David Reece, William Rees, Douglas Parker Robathon, Samson Rosser, Henry Sefton Sheppard Scott, Albert Thomas Seymour, George Harold Simpson, William Upston Staveley, Daniel Thomas, Edwin Thomas, Joshua Thomas, William Thomas, George John Venn, Ivor Warfield, Griffith Watkins, Albert Williams, John Williams, Mansel Treharne Williams, Robert James Williams, Trevor Matthew Williams.

Second Class (*Under-Managers*):—Albert Adams, Thomas Adams, Oswald Allan Ames, Albert Thomas Andrews, Thomas Austin, Thomas Morgan Bevan, George Black, Thomas John Blake, Amos Bound, John Thomas Bowen, William Bowen, William Frederick Bradley, Junr., Thomas John Broome, John Henry Carter, Watkin Charles, William Edward Clay, John Connell, Thomas Cordey, William Crooks, Jenkin Curtis, Leonard Edwin Cutts, Abiathar Davies, Alfred Davies, David Daniel Davies, David Henry Davies, David Lewis Davies, David William Davies, Edward Davies, John Davies, John Penry Davies, Joseph Davies, Rees Samuel Davies, Richard David Davies, Thomas Davies, Thomas George Davies, Thomas Isaac Davies, Uriah Davies, Thomas Edwards, William Edwards, William Austin Ellis, Thomas John English, Archibald Skym Evans, Daniel Thomas Evans, David John Evans, David Morris Evans, Edward Evans, John Lewes Evans, John Thomas Evans, Richard Thomas Evans, Thomas Evans, Thomas Evan Evans, William Evans (Llangennech), William Evans (Trimsaran), William Thomas Evans, Joseph Foster, John James George, David Daniel Gething, Frederick Godwin, Samuel Goodwin, David Griffiths (Ystradgynlais), David Griffiths (Pontyberem), John Griffiths (Ynismeudw), John Griffiths (Cwmgors), John Griffiths (Blaenavon), John Griffiths (Blaina), Taliesin Griffiths, Thomas Griffiths, Thomas Issac Griffiths, James Gwyn, William Hammonds, Ivor Edward James Hares, Albert Harris, John Hart, Benjamin Haynes, Anfield Henry, Thomas William Hicks, Alfred Hinton, Thomas Hoare, Evan Hopkins, John Hopkins, Thomas Arthur Hopkins, Jenkin William Howells, John Howells, Daniel Hughes, David John Hughes, Rowland Hughes, William John Hughes, William Henry Hunt, Evan James, John James, William James, Howell Jeffreys, Daniel Jenkins, Gad Elias Jenkins, Lewis John Jenkins, Oliver Jenkins, Philip Jenkins, William Jenkins, Richard Harding John, Arthur Idris Jones, Daniel Jones, David Jones, Edward John Jones, Edward Phillip Jones, Edwin Jones, Frederick Oscar Jones, Griffith John Jones, Idris John Jones, James Jones, John Jones (Abercrave), John Jones (Tredegar), Joseph Morgan Jones, Noah Davies Jones, Owen Jones, Richard Jones, Walter Rhys Jones, William Jones (Ystradgynlais), William Jones (Gilfach Goch), William Jones (Five Roads), William Benjamin Jones, William Kilsby Jones, William Morgan Jones, Joseph Legg, David William Lewis (Rhymney), David William Lewis (Ammanford), George Reginald Gordon Lewis, Gwilym Lewis, Lewis Lewis, Lewis Jones Lewis, Morgan Rees Lewis, Richard Lewis, Thomas Lewis, William William Lewis, Wyndham Edward Lewis, William Daniel Llewellyn, Frederick James Lowe, William McCale, Thomas Matthews, Robert George Maurice, Daniel Meredith, Frank Mitchard, Walter Mitchell, Arthur Morgan, David Morgan, Idris Morgan, Lewis Morgan, Thomas Lewis Morgan, William Morgan, Matthew Eslyn Morris, Richard Morris, William David Morris, William John Morris, John Mosley, Joseph Munn, Frederick Charles Mutlow, William Edwin Oakey, Edward Oates, David Owen, James Pearce, John Morgan Philipps, Thomas Phillips, Frederick Lewis Pocock, Arthur John Powell, Thomas Powell, Samuel Price, Thomas Henry Price, Vavasor Pritchard, Rees Prosser, David Pugh, Arthur Wallace Rake, Douglas Ramsay, David Rees, Gwilym Rees, James Rees, Jason Rees, Oliver Rees, Taliesin Rees, Thomas John Rees, David Richards, Thomas Roberts, Jenkin Lewis Robins, William Rolfe, William John Rollings, William Rosser, John Valentine Sage, Harold St. Clair, John Saunders, George Henry Savage, David Sims, George Edwin Smith, James Fiander Smith, John Henry Smith, Albert William Steeds, James Stephens, Edward Swain, Alfred Terrell, David Thomas (Nantymoel), David Thomas (Cross Hands), David John Thomas, Edgar Thomas, Howell Thomas, John Thomas, Oliver Thomas, William Henry Thomas, William Treharne, John Truscott, George Turner, Thomas Vaughan Lewis Walker, William Walters, William Oswald Ward, Methusalem Watkins, Thomas Watkins, George Watson, William Robert Giles Wattley, Alfred Webster, Daniel Williams, Evan David Williams, Herbert Williams, Herbert Rhys Williams, John Williams, Junr., John Williams, Thomas John Williams, William Williams, Thomas John Willmott, and Thomas Wright.

PRIZE COMPETITION.

"Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXIII.

This competition is open to all who have not secured first place in Honours or First Class in earlier volumes. Competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of 2s. 6d. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer (with the question attached) must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript. Lettering on sketches should be bold and clear.

Marks will be awarded. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks*; whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

The Competitor in each stage who secures most marks throughout the volume will be held to be the winner in that stage. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured. Each winner will be entitled to and receive the Publishers' Book Prizes, value not less than one guinea, whilst the photo of the successful First Class competitor will be published, and he cannot take part in the Competition of later volumes.

In addition to the foregoing, the Editor will give special prizes to the Competitor in each stage who has the largest number of published answers throughout the volume, the value in case of the Editor's prize being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the first set of questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than

Tuesday, July 30th, 1912.

Answers to the second set of questions to be received not later than Tuesday, August 6th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

——READ THIS: IMPORTANT REGULATION.——

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the foot of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[*The selected answers to the following questions will appear, not in No. 26, Vol. XXII., but in No. 1, Vol. XXIII.*]

FIREMEN.

Q. 1. DUTIES OF FIREMEN.—*How does the 1911 C.M.R.A. affect the duties of a fireman?*

Q. 2. INSTRUMENTS USED IN MINING.—*What is your opinion on the requirement, by the Act, of a Thermometer, Barometer, and Hygrometer to be kept at every mine?*

Q. 3. VENTILATION.—*Which should be the return in ventilating a heading by air pipes—the pipes, or the heading?*

SECOND CLASS OR UNDER-MANAGER'S.

Q. 4. MINES ACT.—*What steps would you take if you found the return from a large district fouled to the extent of 5 per cent. of gas?*

Q. 5. HAULAGE.—*What horse-power of haulage engines will be required to haul in 8 hours 400 tons of coal up a drift 1,200 yards long, rising 1 in 6, endless rope, coefficient of friction $\frac{1}{30}$?*

Q. 6. MINES ACT.—*What examinations have to be made daily under the 1911 Act?*

FIRST CLASS OR MANAGER'S.

Q. 7. HAULAGE ENGINES.—*Find size and give dimensions of engines to haul 500 tons of coal per day of 8 hours, along a road 2,000 yards long, average dip 1 in 15, main and tail rope, 8 hours' hauling per day.*

Q. 8. MINER'S DIAL.—*Sketch and describe an ordinary miner's dial.*

Q. 9. VENTILATION.—*If you found the water-gauge at a pair of separation doors underground different from usual, what conclusions would you draw* (1) *if it was less;* (2) *if it was more?*

[*Answers to the following set of questions to be sent in and received not later than Tuesday, August 6th, 1912; selected answers will appear, not in No. 1, Vol. XXIII., but in No. 2, Vol. XXIII.*]

FIREMEN.

Q. 1. EXPLOSIVES ORDER.—*What are the principal alterations made by the recent Explosives Order?*

Q. 2. VENTILATION.—*A heading 10 feet by 8 feet is ventilated by an air-pipe 2 feet in diameter. If the velocity of the air-current in the heading is 10 feet per minute, what will it be in the air-pipe?*

Q. 3. HYGROMETERS.—*Sketch and describe a simple form of hygrometer.*

SECOND CLASS OR UNDER-MANAGER'S.

Q. 4. GAS TESTING.—*Give simple sketch and description of the caps which will be found on the flame of a Davy lamp for percentages of from 1 to 6.*

Q. 5. HORSES UNDERGROUND.—*State briefly the rules regarding the care of horses underground.*

Q. 6. SURVEYING.—*Give simple sketches of a vernier reading to 3 minutes in three different positions, with short explanation.*

FIRST CLASS OR MANAGER'S.

Q. 7. FANS.—*Give a sketch and describe a Sirocco fan.*

Q. 8. VENTILATION.—*Sketch and describe the arrangements you would make so as to enable the ventilation of a mine to be reversed if required.*

Q. 9. SURVEYING.—*What are (in brief) the alterations made by the 1911 Mines Regulation Act regarding plans and surveys?*

Best Answers Received to Questions In No. 23, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Testing for Gas.

Q. 1.—*Explain how you would use the safety-lamp in testing gas.*

A.—The safety-lamp is acknowledged to be the simplest means for ascertaining the presence of fire-damp present in the mine. Not only can the presence of the gas be readily observed with the safety-lamp, but the percentage present can be determined to a certain extent, this depending upon the skill of the observer who may be using the lamp for testing for gas, and by estimating the size of the gas-cap formed.

Testing for gas with the safety-lamp in the mine requires skill on the part of the person testing, owing to the fact of it being such a delicate operation; otherwise the light is soon lost, this being verified by anyone who has had practical experience in testing for gas. Although testing for gas with the safety-lamp is a delicate operation, demanding skill and precaution on the part of the person testing, yet the presence of fire-damp may be ascertained very easily if the lamp is used in a proper

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

manner, and by one who is conversant with the action of fire-damp upon the flame. This is the principal feature, the effects of fire-damp upon the lamp flame when introduced into its presence, which must of necessity be noticed very keenly by the person testing.

Seeing that this is a personal question, I will endeavour to explain how I would use the safety-lamp for testing gas, assuming of course that the gas referred to means the common and dangerous gas, fire-damp, met with in coal mines.

Before using the safety-lamp for ascertaining its presence, I would satisfy myself that the lamp to be used was perfect in construction, and every part properly put together and securely locked. Having in my possession a perfect lamp, I would proceed to ascertain the presence of fire-damp by what is known as the accumulative test. By this, I will suppose that I enter a working place suspected to contain fire-damp. Instead of lowering the flame of the safety-lamp as my first operation, and which is very common when testing, I would make a preliminary test with a large or full-sized flame, so as to make sure that gas is not present in great quantities. By testing with a large flame, should there happen to be a great accumulation present, its action upon it can be readily observed, as it causes the top of the flame to elongate or spire up towards the gauze, and from experience gives the person testing a better chance of retaining his light, more so than commencing to test with a mere speck of flame in the lamp.

Having failed to discover or notice any great elongation or spiring during the process of testing with a large flame, I should conclude that fire-damp was not present in any great quantity, owing to the fact that the effect or action upon the flame was not manifest or discernible.

I would use my safety-lamp for ascertaining the presence of fire-damp by what is known as the percentage test. This I should endeavour to accomplish by carefully lowering the flame of the lamp until its luminosity has disappeared, leaving only a mere speck of light at the tip of the wick. If fire-damp is present, a small gas cap of pale blue colour will form itself just above the mere speck of light. The size of the gas cap will vary according to the amount or percentage of fire-damp present, and which can be calculated according to the knowledge of the person testing, it being stated that 2 per cent. of fire-damp will produce a gas cap somewhere about $\frac{1}{4}$ inch long, and 3 per cent. of fire-damp will produce a gas cap about $\frac{1}{2}$ inch long upon a small flame, in the ordinary safety-lamp when testing.

In conclusion, the safety-lamp can be used in the above manner for ascertaining the presence of fire-damp, indicating its presence by the elongation or spiring of the large flame in the accumulative test, and the formation of the small gas caps above the mere speck of flame in the percentage test.

Thos. Gaskell, 138, Downall Green Road, Bryn.

[NOTE.—In our own opinion, the only proper way to test for gas where its presence is suspected is to first try with the flame at its normal height. If gas should be present in explosive quantity the resulting explosion will be less violent than if the test had been made with the flame at its smallest possible size, because the explosibility of the gas will be neutralised by the presence of the products of combustion of the oil flame. Should such preliminary test give a negative result, then it will be quite in order to try for the presence of gas with the reduced flame, as at the most nothing more than a cap will be observed, as the mixture must be below firing point, as shown by the first test.—C.C.M.]

Geo. Bosher, J. Twigger, F. Cooke, D. McBurnie, T. Garbett, W. Hodgson, Junr., S. Beardsley, W. J. Jenkins, W. Hawthorne, A. Graham, E. Smith, J. H. Cumberbatch, J. Cheetham, C. Simpson, S. F. Middup, Joseph Taylor, G. Brown, J. Bradshaw, T. Evans, Junr. (*12 marks each*).

W. Brooks, W. Williams, J. Brooks, J. C. Rodman, L. J. Jones, G. C. Brown, J. W. Heywood, F. Mitchard, G. Davies, T. G. Lippitt, B. W. Wheeler, J. Taylor (*8 marks each*).

E. Parry, L. J. Thomas (*4 marks each*).

Ventilation.

Q. 2.—*What is the effect of providing large air-ways and having the air travel at a low velocity?*

A.—A large quantity of air passing at a low velocity will give great efficiency in ventilation, and the air-ways should be made as large as possible. By having the ventilation in this condition many good effects may be obtained. First, the conditions will favour the dilution of the gases given off from the strata, &c. Current agitation prevents diffusion, therefore the less the speed of the air-current the more favourable the conditions for diffusion. The working conditions will be better for the miners. The air travelling at a low velocity will not be so uncomfortable as air travelling at a high velocity. Further, the conditions will be safer. Safety-lamps are constructed subject to conditions, one of which is that the air-current in respect to the lamp must not attain a greater speed than a fixed maximum. Should this be contravened the flame of the lamp will be deflected, and thus come in near contact with the gauze. Then should the current be of an explosive nature danger would be caused, as it would be possible for it to ignite. The resistance in relation to the quantity passing will not be so great as the resistance due to the passing of the same quantity through smaller air-ways. Thus the pressure producing ventilation will not be so great, and a saving will be derived from the ventilating means. Should the air-ways throughout a mine be made large and near the circular in shape as practically possible, then the ventilation would be very near the "adequate," as required by the Mines Act. Yet such is hardly possible, due to the changing conditions of the air-ways caused by strata settlement, &c., therefore the ventilation is so arranged that the current sweeping the working faces is at the required velocity, due regard being made to safety. In the main intakes little if any inflammable gas is prevalent, and in the returns where inflammable gas is carried in the air-current, special safety-lamps are used of such construction that the flame is never deflected even when the current is passing at a high velocity.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

[NOTE.—Suppose we require 100,000 cubic feet of air per minute in a mine, and that this air has to pass along an air-way 600 yards long before splitting. Let us see what will be the difference in the pressure required to pass that air through the air-way, first assuming it to be 10 feet wide by 10 feet high, and second 5 feet wide by 5 feet high. We take the formula :—

$$p = \frac{ksv^2}{a}$$

In the first case s will be $40 \times 1800 = 72{,}000$ square feet, $v = 1$, and $a = 100$, and we have

$$p = \frac{k \times 72000 \times 1}{100} = 720k.$$

In the second case s will be $20 \times 1800 = 36000$, v will be 4, and a will be 25. We have

$$p = \frac{k \times 36000 \times 4}{25} = 5{,}760k.$$

Assuming whatever value we like for k, the pressure in the latter case will be 8 times that in the former. Seeing that the quantity is the same in each case the horse-power required will be 8 times as much as in the case of the larger area with the slower moving current. In fact, if a value be given to k and the two results worked out, it will be seen that an almost impossible water-gauge would be required to drive this air through the air-way of the smaller dimensions. The preceding example shows clearly the effect of providing a large area, and a comparatively low velocity.—C.C.M.]

S. F. Middup, D. McBurnie, J. Taylor, F. Cooke, S. Beardsley, T. Gaskell, J. C. Rodman, G. Brown (*12 marks each*).

G. Davies, A. Wright, W. Williams, F. Mitchard, L. J. Thomas (*8 marks each*).

Shot-Firing.

Q. 3.—*In what way is shot-firing dangerous in a mine containing inflammable gas?*

A.—Fire-damp is an inflammable gas, and is prevalent in nearly every mine. An atmosphere containing about ten per cent. of it forms a very explosive mixture, therefore it

is necessary that great care be taken to prevent ignition. The chief cause of danger in respect to inflammable gas in mines is that of shot-firing, because when such detonates flame is given off more or less. Of course, the above is in respect to ordinary powder. In the interests of safety powder is never allowed in fiery mines. A special explosive is used for the purpose termed "Permitted," this, when used properly, being incapable of producing flame. As stated an atmosphere containing between nine and ten per cent. of fire-damp forms a very explosive mixture. Assume such mixture is present in a working place, and a shot fired in the strata adjacent to it. Further assume the shot to be one of permitted explosive, but charged incorrectly. When it detonates it would cause flame to be produced (should the charging be too heavy for the work or too light for the work), and this flame would ignite the inflammable mixture referred to, and thus be the cause of an explosion. Thus the dangers attendant upon the use of explosives in the presence of inflammable gas. Various means may be adopted to prevent the ignition of explosive mixtures of fire-damp and air when shot-firing is being done, one being the using of a water-cartridge. Although under certain conditions fire-damp is a great danger in mines it is not the most dangerous element, coal dust taking the precedence. In places where fine coal dust is present a very low percentage of gas is sufficient to cause an explosion. Coal dust may cause an explosion in places where no gas is prevalent. In the case of a shot-hole charged too heavy the concussion of the shot due to detonation would raise the dust, causing it to become finely suspended in the air. The excessive flame produced from the too heavy charge would ignite the mixture, and thus cause an explosion throughout the mine. Nearly all mines are more or less dry and dusty, and contain inflammable gas, therefore great care should be taken when shot-firing, because when not fired correctly powder provides the means of igniting explosive mixtures of fire-damp and air, and coal dust and air.

Shots fired in accordance with the Mines Act reduce all dangers to the minimum. In the first place, no shot-firing is allowed when gas is present, thus in this respect prevention is considered, and rightly so, better than any after cure. In the interests of safety the Act further requires the under-cutting greater in depth than the shot-hole, the shot-hole clear of all breaks or fissures, the charging, tamping, &c., done correctly, the firing means efficient and incapable of producing flame, and the firing of all shots to be done by a competent person appointed for the purpose in writing by the management, his wages not to be dependent upon the amount of mineral gotten.

In estimating the amount of explosive for each shot-hole a great deal depends upon the judgment of the shot-firer, the best teacher in this respect being practical experience. The work requiring to be done by the exploding of the shot should be thoroughly considered, and the amount of explosive so gauged that no excessive flame will be given off from the detonation. As stated, too much explosive will cause excessive flame, and too little a blown-out shot, occurrences which are the direct means of causing an explosion should the atmosphere be dangerous.

Summing up we find that shot-firing is dangerous in a mine when flame is given off from the detonation of the explosive. The average conditions of working places are such that in most cases the prevailing atmosphere is explosive. Such danger is caused by the fine coal dust and inflammable gas. Dangers due to the firing of shots will be greatly if not altogether reduced should the Mines Act *re* the same be thoroughly carried out. In places where coal dust is present watering or other treatment should be applied to render it harmless. Before the charging of the shot-hole a thorough examination should be made for gas. If found prevalent shot-firing should be suspended in the whole of the district where found until the gas has been efficiently cleared. It will be understood should there be no gas and dust, there will be no danger. Thus ordinary powder is allowed to be used in non-fiery mines.

C. Simpson, 32, Gladstone Terrace, Usworth Station.

T. Evans, Junr., W. Williams, J. H. Cumberbatch, J. C. Rodman, T. Gaskell, W. J. Jenkins, T. Garbett (*12 marks each*).

D. MeBurnie, G. Davies, J. Taylor, L. J. Thomas, A. Graham, A. Wright (*8 marks each*).

E. Parry, W. Brooks, J. Brooks (*4 marks each*).

Geology.

Q. 4.—*What is coal, and how may the constituents of coal be classified?*

A.—Coal is composed of matter derived from plants, and may be described as mineralised vegetation. It is highly probable that most of the coal seams were formed on the spot where the plants grew, abundant proof of this being given by the fact that in the underclay immediately beneath the coal we have roots of trees (Stigmaria).

Mineralisation of Coal.—The masses of vegetable matter which formed the coal were consolidated by pressure and heat during an immense period of time, during which period chemical changes took place, the volatiles of the wood being first expelled. After this the oxygen and hydrogen would join together to form water (N_2O), a part of the carbon would join with the oxygen, and another part would join with hydrogen, forming successively carbon dioxide and carburetted hydrogen. Thus the hydrogen and oxygen would be diminished, the carbon becoming more concentrated, forming successively peat, lignite, bituminous, and anthracite coal.

Mode of Occurrence of Coal.—In describing the mode of occurrence of coal, I consider it advisable to make slight reference to shale and ironstone, these being frequently found in the immediate proximity of coal seams.

It is evident from the order and nature of different deposits that they were formed during a period of very slow depression, and that at intervals through a long period of time the conditions on the earth's surface became very much altered. Thus, for example, a forest which had been the scene of once luxuriant vegetation would be submerged, and a deposit of shale or sand of considerable thickness would cover the forest. When this was filled up to the level of the water a new land surface would be formed, upon which another growth of vegetation might take place, so that, after the lapse of an immense period of time, another forest would be submerged, forming another stratum of coal. In some cases the material held in suspension by the water would be iron, associated with other ingredients, and this being deposited immediately above the coal would form an ironstone strata.

Classification of Coals.—Coal may be classed as (1) Lignite or Brown Coal; (2) Bituminous Coal; (3) Anthracite Coal; (4) Cannel Coal.

(1) *Brown Coal or Lignite.*—This is a more recent origin than the true coal, occurring as it does in rocks which have been deposited at a more recent age than the Palæozoic; it is therefore an intermediate between wood and coal. This coal is widely distributed throughout Europe, but in England only about one deposit has yet been discovered, and that one in Devonshire. There are three varieties oflignite.

(*a*) *Bituminous Wood* shows a woody structure, has a brownish colour, and is known by the name of wood coal.

(*b*) *Brown Coal or Lignite* is a more compact and harder coal, and does not show such a woody structure.

(*c*) *Pitch Coal* is black or brownish black, and breaks with a conchoidal (*i.e.*, shell shaped) fracture. It shows a woody structure, and in colour it may be either shiny or dull.

The following is an analysis of Bovey Lignite, as given by Dr. Percy :—

Carbon	66·31
Hydrogen	5·63
Oxygen	22·36
Ash	2·7

Lignite kindles easily, burns with a long flame, and has a very low calorific power, and for this reason it is used very little for metallurgical purposes.

(2) *Bituminous Coal.*—This coal burns with a yellow, luminous, smoky flame, very similar to the mineral bitumen, after which it has been called. This class of coal is usually black in colour, and always soils the fingers when handled. These coals belong to the Carboniferous formation principally.

Classification of Bituminous Coals.—(*a*) Non-caking Coal; (*b*) Gas Coal; (*c*) Furnace Coal; (*d*) Coking Coal.

Analysis of Coals.

	Carbon.	*Hydrogen.*	*Oxygen.*
	%.	%.	%.
(0) Non - Caking Long Flame Coal	77 to 80	4·5 to 5·5	15 to 19
(2) Gas Coal	80 to 85	5 to 5·8	10 to 14
(3) Furnace Coal	85 to 89	5 to 5·5	5 to 11
(4) Coking Coal	88 to 91	4·5 to 5·5	5 to 6

Having given the essential constituents of the various kinds of bituminous coals, let us now briefly give a description of the different varieties, and see what practical purposes they serve.

Non-Caking Coal.—In these coals there is a large amount of hydrogen and oxygen. When distilled they yield a larger quantity of gas. These coals are usually black or brown in colour, and of a very hard nature, such as the Splint Coal of North Staffordshire and Scotland. Owing to their hardness they are usually used for blast furnaces. The specific gravity of these coals is about 1·25. They yield on distillation large quantities of tarry matter, and burn with a long, smoky flame. They also contain a large quantity of nitrogen; if we have present 1 to 1·5 per cent. of nitrogen, this will upon distillation in the blast furnace yield ammonia equivalent to 25lb. of ammonium sulphate per ton of coal consumed.

Gas Coals.—These coals are hard, dense, and usually black in colour, having a specific gravity of 1·3. These upon distillation, as their name implies, yield a large quantity of gas, from 10,000 to 12,000 cubic feet per ton of coal consumed. They also contain nitrogen and yield ammonia. They burn with a long luminous flame, and are suitable for reverberatory and blast furnaces.

Furnace Coals.—These are very valuable for general use, there being many varieties which are suitable for various purposes. They are used for house coals, for gas-making purposes, and furnace work. They burn with a bright, luminous flame, and upon distillation yield about 75 to 80 per cent. coke.

Example of analysis of a sample of furnace coal:—

	%.
Volatile Matter	30
Coke	70
Fixed Carbon	63
Ash	6
Moisture	5·85

Caking Coals.—These upon heating soften and become pasty, and agglomerate into a mass of coherent coke, in some cases as much as 80 per cent. They burn with a short flame, are used for household and furnace purposes, and also for making coke as mentioned above.

Anthracitic Coals.—These, though classed among the bituminous group, nearly approach to anthracite. In colour they are bright black, and soil the fingers but slightly; they are compact, ignite with difficulty, and burn with little flame or smoke. Specific gravity, 1·3 to 1·4. They are sometimes called smokeless, steam coal, or blind coal. These coals give off very little gas, but yield about 90 per cent. of coke upon distillation.

Anthracite.—This class of coal represents the last and most perfect stage of mineralisation. It contains from 96 to 98 per cent. of carbon, and in nature is very hard and brittle. It burns with little flame and no smoke, but gives out intense heat. Its colour is deep black, and it breaks with a conchoidal fracture. By some it is looked upon as being metamorphosed by the action of heat agencies. Specific gravity, 1·5.

(4) *Cannel Coal.*—Cannel differs from ordinary coals both in mode, formation, and composition, and must be considered apart. It is close and compact in texture, dull black in colour, and breaks with a conchoidal fracture. It burns with a long, luminous flame, from which the name is derived (cannel or candle coal). When burning it decrepitates with a cracking sound (hence the name parrot coals). It yields a large quantity of gas, from 10,000 to 12,000 cubic feet per ton consumed, of highly illuminating quality. The specific gravity of this coal is about 1·27.

In answering this question I have been slightly assisted by back notes taken at the Stoke-on-Trent Mining School.

Wm. Hawthorne, 26, Bridge Street, Mount Pleasant, Fenton.

D. McBurnie, C. Simpson, S. Beardsley, A. Graham, W. Williams, J. C. Rodman, J. Bradshaw, T. Evans, Junr., T. Gaskell, H. Thomas, L. J. Thomas, A. E. Helps (*12 marks each*).
E. Jones, J. Brooks (*8 marks each*).
E. Parry, G. Davies (*4 marks each*).

SECOND CLASS.

Coal Dust.

Q. 5.—*In what mines is coal dust most abundant? How is it formed?*

A.—Coal dust is found more or less in all dry mines, but shallow mines are rarely troubled by its presence, due to the fact that in most cases they contain a great deal of water. The mines mostly found to be affected to any dangerous degree by fine coal dust are the following:—

1.—The structure of the coal itself greatly influences its dust production. For instance, take bituminous coal, which possesses a cuboidal structure, resulting from the planes of fracture in the coal crossing at right angles to each other. Usually in this coal the horizontal planes of fracture coincide with those of stratification, the coal having gained its thickness by the agency of lamina. Coal consists, or is constructed of, thin leaves or lamina of mineralised vegetable matter. This peculiar structure in most coals is possibly the chief reason of the formation of dust in the first case, because some coal seams are so hard and compact as to practically make the presence of dust impossible, but it is found that, even in mines with strong coal, dust prevails; this is due chiefly to the grinding, &c., which takes place on the haulage roads. Consequently, we can safely state that dust is originally produced at the working faces, the amount produced being more or less according to the nature and character of the coal, as mentioned above. Coal of a dense and compact character will produce, in the first working, very little dust, but on the other hand, thick friable seams, with coal of a brittle nature, generally produce a large amount of dust. Of course the mode of working the coal also has an influence upon the dust production; for instance, manual undercutting or holing produces a greater proportion of small than in the case of machine holing.

2.—Coal dust of a very fine and dangerous nature is often seen in abundance in shaft bottom sidings and intake roadways in mines which have the screening plant near the downcast shaft.

3.—A great deal is also in mines which employ badly-constructed trams, having open sides or ends, through which small particles of coal fall on to the road. The same applies to mines in which it is the practice to load above the level of the trams, in which case accidental derailment of a tram is a fruitful source of dust.

4.—From a dust point of view a mine which utilises the returns as haulage roads has less dust than a mine in which the intakes are employed for the purpose, because when loaded trams travel rapidly against the air-current some particles are blown off which will in time be crushed up into a very fine state of division. The same applies when employing the downcast for winding coal.

5.—Coal dust is very abundant in some mines on account of having adopted the long wall retreating system. In this case the haulage roads are driven in the coal, and unless every precaution is taken to prevent the grinding up of the coal in the sides, the conditions are very favourable for dust accumulations. This also applies to the various systems of pillar working, in which mines the pillars, if too small, will induce creep, and will crush the corners, &c., of the pillar into slack, which will in time develop into fine dust. Hence in thick seam mines dust accumulations are not uncommon.

6.—The only exception to the above list of mines which induce the dust danger is No. 1, in mines which work hard and compact coal. It is usually the practice to resort to blasting, and as is known, this operation, no matter whether conducted in hard or friable coal, always yields more or less dust, consequently it is always unsafe to say that coal of a hard and dense nature produces no dust.

The sources of accumulations of coal dust in mines may be briefly enumerated as follows:—

1.—It has been found that a large quantity of the most dangerous dust near pit bottoms and intakes generally, has been traced to the action of the fan, in drawing the dust in suspension near the screen into the downcast and thereby propagating it throughout the main roadways of the mine. This dust is usually of a fine nature, and very pure, and according to "M.E.," in his interesting articles in this Journal, more than 98 per cent. of this dust from the screens can be made to pass *through* a 240 mesh. Hence this dust when present in mines is exceedingly dangerous, and should receive immediate attention.

2.—Another very fruitful source of dust in mines is traced to (*a*) falling off badly constructed mine wagons; (*b*) coal blown from the top of loaded trams when in rapid motion against the air; (*c*) falling off trams which have been filled above the level of the iron (this is a common practice here in South Wales); (*d*) some dust and particles of coal are always blown off tubs when ascending the shaft by going contrary to the air-current; and (*e*) in cases where no revolving tipplers are employed, it is often found that some coal is consistently left at the bottom of the tram after unloading at the screens.

3.—Coal dust resting on timbers and on the floor of roadways is being continually set in a state of agitation by the travelling of men and horses, and by the running of wagons, &c. Every little piece of coal which falls off a passing tram or from the roof or sides will ultimately be crushed to a very fine state of division by two sources: (*a*) The disintegrating action of the air and moisture; and (*b*) the continual travelling of men and horses. The coal dust resting on the floor and ledges of a roadway is rendered more and more dangerous by each passing tram. When trams are loaded above the level, derailment and continuous jolting, due possibly to a rough and uneven road, always produce more or less dust.

4.—Hand holding produces proportionately more small than machine work, because in the former case the holing takes the tapering form, whilst in the machine work the cut is uniform throughout its entire length.

5.—Face conveyors, especially if a brisk air-current circulates the face, provide another source of dust formation. It is essential that the bottom of the conveyor should be as dust tight as possible, to prevent any coal falling through the crevices, &c., in the conveyor.

6.—Dust of a coarse nature is produced to a great extent near the edges of pillars by the gradual grinding up of the coal by the action and influence of the top and bottom pressure.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[Note.—In our opinion, a large proportion of the dust found in the intake air-ways of a mine has been carried down the shaft from the screens. Take a mouthing leading out of a downcast shaft, which mouthing is merely used for ventilation purposes. If the screens are close to the top of the shaft, most probably the road leading from that mouthing will be filled ankle-deep with the very finest of coal dust. This cannot have come from anywhere but the screens. The pity is that although in many mines there is ample watering of the haulage roads, no efforts are made to deal with the dust on such intakes where no haulage takes place. A further cause of dust on the haulage roads is the fact that open-ended trams are used. This greatly increases the amount of dust to be dealt with, or that ought to be dealt with.—C.C.M.]

J. A. Withington, E. Ambrose, J. Grundy, F. Brooks, T. Llewellyn, A. Stephens, A. B. Dawson, W. Potter (*12 marks each*).

J. Parkinson (*8 marks*).

Ventilation.

Q. 6.—*About what proportion of the pressure spent on a ventilating current is used on friction, and on giving velocity respectively?*

A.—An understanding of the general laws and principles upon which the friction of air in mines depends, is of great importance in order to know how to reduce such friction to its lowest possible amount, and by this means obtain the maximum quantity of air from our ventilator.

A difference of pressure of only one pound to the square foot in the open atmosphere gives rise to a wind in the air, having a velocity of 28·8 feet per second, or more than nineteen miles per hour, which is nearly equal to the highest velocity of the air current in the upcast shafts of coal mines. However, in practical mine ventilation it is found to be necessary to employ a much higher pressure than one pound to the square foot in order to induce this velocity; in many cases it is necessary to employ from ten to twenty pounds per square foot to create it, and this pressure is equal to the weight of an air column 130 to 260 feet high, instead of only 13 feet high, as in the open air. The reason for this great difference of pressure which is required to generate velocity in the open atmosphere and in mines arises from the friction which the air current encounters by rubbing against the sides of the mine roadways whilst circulating. Every square foot of surface which is exposed to the air travelling along the passages of a mine is pressed by the air to about a ton of pressure; the consequence is that extra pressure is necessary in order to overcome the friction arising from this immense pressure. Suppose, for instance, we find that the terminal velocity of the air escaping from a mine by an upcast shaft is such as to require a pressure of one pound per foot, or 13 feet of air column, to create it, on the supposition that there prevailed no friction; and if, at the same time, we find that the actual pressure employed is ten times as much, or equivalent to ten pounds per square foot, we learn from this nine pounds out of the ten pounds per foot are required to overcome the friction of the air when coming in contact with the sides of the roadways, &c., the other one pound per foot, or one-tenth of the whole pressure only, being necessary to give rise to or create velocity, and this is usually the case in all mines. Friction then which is due to the rubbing of the air against the roof, floor, and sides of the air-ways in the mine, is really the greatest obstacle to be overcome by the ventilating pressure or power; on the other hand, the force required to create motion in the air, apart from friction, being very small in comparison. This is usually the case, however, in coal mines; metallic mines may be slightly different.

In order to show a sort of proportion between these two factors, *i.e.*, the comparative amounts of pressure expended upon creating velocity in the air, and upon surmounting the frictional resistances it meets with in the mine excavations, respectively, the following cases are given, the pressure due to velocities being those due to the final velocities at the tops of the upcast shaft:—

Colliery.	Pressure in Air Column due to Velocity.	Pressure in Air Column due to Friction.	Total Pressure Employed.	Proportion due to Velocity & Friction respectively
	Ft.	Ft.	Ft.	
Hetton Colliery (1st Case)	10·43	179·88	190·31	1 : 18
Hetton Colliery (2nd Case)	12·37	212·63	225·00	1 : 17
Haswell Colliery ..	13·84	140·66	154·50	1 : 10
Tyne Main Colliery ..	25·70	177·50	203·20	1 : 7

From the above table it can be seen that at Hetton Colliery no less than eighteen out of a total pressure of nineteen were used to overcome friction, and only one upon creating velocity in the air. The proportion given in this example is high.

At Haswell Colliery ten parts out of eleven of the ventilating pressure were spent upon the friction encountered by the air, and only one part out of eleven upon generating its final velocity as the top of the upcast shaft.

At Tyne Main Colliery seven parts out of eight of the ventilating pressure were consumed by the friction, and only one part in eight upon the velocity of the air at the top of the upcast shaft.

Consequently, as is shown by the above actual examples, the greater portion of the pressure applied to the air in mines is spent, not in imparting speed or velocity to the air, but in overcoming the great friction which it meets with circulating the air-ways. Therefore it is perceived that the adequacy of the ventilation in a mine, and hence the comfort and health of the miners, depend almost entirely upon the amount of friction that the air has to contend with; by reducing it to the

lowest practical limit we thereby increase the quantity of air from any mode of ventilation we may employ, no matter whether it be a furnace, fan, or any other contrivance.

Assisted, especially in the case of the examples given, by *General Principles of Ventilation*, by the late J. J. Atkinson.

A. Nelson, Maes-y-Dyffryn, Glyn Neath, Glam.

J. Grundy, E. Ambrose, F. Brooks, A. Stephens, W. Potter (*12 marks each*).

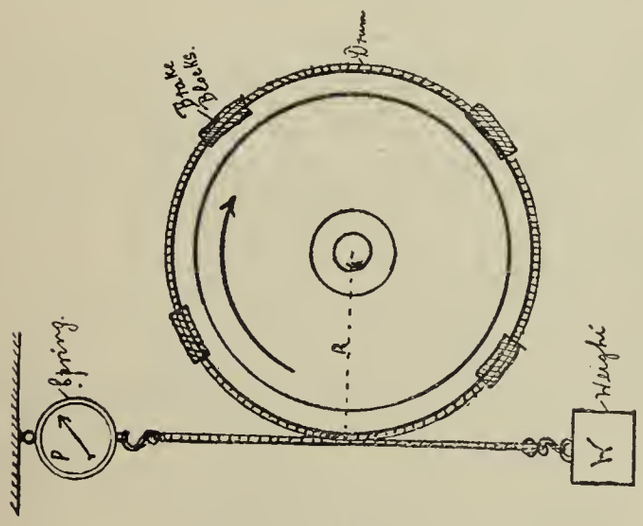
Mechanics.

Q. 7.—*What do you understand by the efficiency of a machine, lost work, useful work, and total work?*

A.—In order to obtain a clear conception of the above-mentioned terms it would be advantageous to take each of the terms in the reverse order to that in which they are given.

Total Work.—When it is necessary to illustrate the total work done by a machine, the machine usually adopted by mining students is a stationary steam engine.

To start at the commencement, we know that a force is said to be doing work when it acts through a distance overcoming resistance. The quantity of work done is proportional jointly to the magnitude of the force and the distance through which it acts, the distance being always measured along or parallel to the line of action of the force. The unit of work used by engineers in this country is the foot-pound, and is that quantity of work which is done when a force of one pound acts through a distance of one foot in its line of action.



Illustrating Question 7.

Then again if work is imparted to a body so that it stores up and is capable of giving it out again, the body is said to possess Energy, and since we know by the principle of the conservation of Energy that man is not able to create or destroy energy, but is only able to transform it from one form into another, we realise its extreme importance to the engineer. Thus if we impart to any machine a certain quantity of energy, and no energy is lost in the machine or used to coil up a spring belonging to the machine or do any other form of work in the machine, then the machine will deliver an exactly equal quantity to that given to it. It cannot deliver more, for then it would create energy, nor can it deliver less, for then energy would be destroyed in the machine. In practice it is impossible to construct a machine in which there is no energy, whether by the rubbing of the surfaces on one another, by churning the atmosphere, or by the development of sound and other causes. But we can assert about all machines—Energy supplied = Energy given out + Energy lost in overcoming resistances. Therefore in ordinary engines with pistons reciprocating in cylinders, the energy delivered to the engine is measured from the diagram of work done on the piston.

These diagrams are drawn by means of an instrument called an "indicator." The essential parts of an indicator consist of a small cylinder which can be connected with the cylinder of the engine by means of a "cock." A piston moving in this small cylinder is controlled by a spring. The elastic properties of this spring cause the piston to take up a definite position in the cylinder, depending on the pressure exerted on it. The movement of the piston is communicated by linkwork to a pencil, the linkwork being so arranged that a straight line motion is given to the pencil. The pencil takes up a position corresponding with the pressure in the cylinder. A paper, stretched over a small drum, is caused to move transversely under the pencil, being driven to and fro by being connected to some part of the engine, so as to give a faithful copy of the motion of the piston of the engine to a reduced scale. When the pencil is pressed on the paper, the indicator being connected to one end of the engine cylinder, it will now trace a curve showing the pressure on the piston at any part of the double stroke of the engine. From this curve the average pressure on the piston may be found.

Assuming we know the area of the piston, length of stroke, and number of revolutions made by the engine per minute, it is easy to find the total work done by the engine by using the well-known formula $\frac{PLAN}{33000}$, where P is the average steam pressure, L = length of stroke in feet; A = area of the piston in square inches; and N = number of revolutions per minute; 33,000 = number of foot-lb. = 1 horse-power, so that the answer obtained would give us the horse-power of the engine. (Indicated Horse-Power).

Although we have expended a certain amount of energy into our engine, we must not expect the engine to give out as much power as was put into it, for previously stated reasons, therefore the useful work done by a machine = Work put in — Work necessary to overcome friction of the respective parts of the machine.

The useful work done by a machine is called the Brake Horse-Power, and may be estimated by passing a double rope round the wheel, and held in that position by means of loosely fitting wood blocks secured to the rope. One end of the rope is attached to a spring balance, the other carries a load Wlb. (see *Figure* 1). On nothing the direction of rotation of the wheel, it will be noticed P is helping to turn the wheel, whilst W opposes rotation. The friction of the ropes on the rim communicates these forces to the wheels.

Let R = radius, in feet, to the centre of the rope, then— $WR - PR = R(W - P)$ will be the net opposing moment in pound-feet, if W and P are in pounds.

Where N = number of revolutions per minute, Work per minute = $2\pi RN(W - P)$ ft.-lb., and

$$\text{H.P.} = \frac{2\pi NR(W - P)}{33000}.$$

Lost Work.—The work done by a machine is said to be lost when the energy transmitted to it is used up by the machine, in overcoming frictional resistances, set up by the moving parts, so if the machine is to do useful work we must supply energy sufficient to make good that lost by the resistances in the machine.

The efficiency of any machine is measured by the ratio of energy actually given out as useful work to the energy supplied, or

$$\text{Efficiency} = \frac{\text{Useful work done} \times 100}{\text{Energy supplied}} = x\ \%.$$

Assistance received from Duncan's *Applied Mechanics*.

Alfred Stephens, Clifton Buildings, Cwm, Mon.

Jas. Grundy, J. H. Mee, F. Brooks, A. Nelson, J. A. Withington, E. Ambrose, J. J. Staley, A. B. Dawson, W. Booth (*12 marks each*).

Boring.

Q. 8.—*What are the different purposes for which boring is used in mine operations?*

A.—I would like to say at the outset that there is no branch of mining which has such a wide range of operation as boring, seeing that it is entirely due to this operation that the future

mining fields are proved, this being the initial stage; and only if feasible and worthy of capitalising are they then developed, so it is apparent that the utility and adaptability of the different systems are of great importance owing to the widely different conditions met with in possibly extreme districts, without local facilities for repairs or alterations. The different purposes for which boring is used in mine operations may be divided under two main heads, (1) Surface Boring; (2) Underground Boring.

Under (1) heading we find this the surest practical aid which comes to assist the research of geologists in the discovery of coal seams or to prove the more or less probable extension of a known coalfield. In the latter instance the question always is to find coal beneath strata of a newer formation, by which the true coal-bearing beds are covered up and concealed. Then as a preliminary operation in mining, boring is the most satisfactory method of gaining knowledge as to the depth, thickness, quality, and number of coal seams or other bedded mineral deposits, the area such occupy, or their continuity over a certain area. Valuable information is also afforded as to the nature of the strata bored through, the amount, direction, variations of the dip of the strata, and existence of water-bearing rocks or any great faults; and sometimes in making communications for the passage of haulage ropes or for the purposes of ventilation. The trouble and cost of pumping water in a sinking shaft may be saved sometimes by draining off the water through a bore-hole to another shaft. Moreover, bore-holes may be made and lined with tubes and used with considerable economy for conveying steam or compressed air direct from the surface to underground engines, or for raising water from underground pumps, in place of long lines of pipes. Thus we may gather that we can determine with substantial accuracy the nature of the strata at a much less cost and more quickly than by sinking or by driving drifts. So much then for heading (1).

Under (2) heading bore-holes can be employed for the purpose of ascertaining the nearness of old workings likely to contain water or gas. Bore-holes can be made to serve a very good purpose under such conditions, especially so from the standpoints of safety and economy respectively; because it sometimes happens that the plans of (say) ancient workings have proved to be inaccurate, and serious accidents have occurred in many mines through a feature of this kind by holing into them accidentally and thus causing a sudden inrush of water or gases when not expected with fatal results. We find that boring is essential to comply with the C.M.R.A., because General Rule 13 states that where a place is likely to contain a dangerous accumulation of water the working places approaching such place shall not, at any point within 40 yards of it, exceed 8 feet in width, and shall have one bore-hole at least 5 yards in advance near the centre of the place, and sufficient flank holes on each side of the place or heading. When heavy pressures of water are expected the boring of the holes is performed by having a fixed pipe and valve inserted into the mouth of the hole. The boring rods are made to work through this pipe and valve. When the boring is completed and the rods extracted, the water can be prevented from flowing out in any great quantity by simply closing a valve which is attached to the pipe. By having bore-holes and a pipe inserted with a pressure gauge attached, the pressure of either water or gas can be readily ascertained. An excellent machine for this particular purpose is the Burnside. A very good point about this apparatus is that before starting on its work it can be tested up to a pressure of 600lb. per square inch by means of a little hydraulic pump and pressure gauge attached.

It has been found by experiments that gas also exists in coal in some seams at enormous pressures. Mr. Lindsay Wood carried out a series of such experiments in the county of Durham, proving the high pressure at which gas is pent up in the coal. The same were accomplished by boring long holes into the solid coal, and having pressure gauges attached. He found in many instances very high pressures indeed were obtained, reaching as high as 461lb. per square inch.

In many instances the quantity of gas from bore-holes has been utilised for lighting purposes, being conveyed off by pipes from the bore-hole. Bore-holes have been utilised for piping off oils under a variety of circumstances, and prior to sinking wells for water we find in many instances bore-holes put down first. They have been put down extensively in Pennsylvania as a means of tapping petroleum oil, which is found in varying quantities in that State. I don't know exactly whether I shall be in order if I term boring and drilling one and the same operation; truly speaking they may be called identical terms due entirely to the fact that bore-holes and drill-holes are somewhat similar. Yet we cannot get beyond the fact that drill-holes only tend to serve one purpose, *i.e.*, for blasting. Nevertheless bore-holes or drill-holes are put into any material when blasting has to be resorted to. Again bore-holes are essential for the application of these mechanical contrivances as substitutes for blasting, such as the mechanical wedge, the hydraulic wedge, &c. Boring upwards is sometimes resorted to from an underground drift to prove a seam above; also in cases where faults are met with to try and find the continuity of the seam if any likely to be present. Hence we can plainly gather from the aforementioned that boring is an operation which covers a wide area in mine work, because it lends itself to a variety of circumstances, with beneficial results, especially from a standpoint of safety.

Slightly indebted to No. 14 of the present volume.

JAS. GRUNDY, Wigan Road, Bryn.

J. H. Mee, E. Ambrose, J. A. Withington, A. Nelson, A. Stephens (*12 marks each*).

W. Booth, T. Mather, W. Potter, A. B. Dawson (*8 marks each*).

FIRST CLASS.

Sinking.

Q. 9.—*What are the principal points to be considered before laying off shafts?*

A.—The question as to the position of the shafts is one which requires serious deliberation, as the commercial success of the colliery depends to a great extent upon the chosen position. Obviously, the proper working of the colliery may be seriously handicapped and impaired by an injudicious choice. The position of the shafts depends upon a variety of circumstances, and every point should be given separate and careful consideration. In the choice of a site, the circumstances governing the position may be classed under two heads: (1) Surface considerations; (2) underground conditions.

Surface Considerations.—The surface considerations in many cases outweigh the underground conditions. The chief surface conditions are: (1) The terms of the lease and extent of the leasehold. (2) Surface wayleaves and transport facilities. (3) Available supply of good water for boilers, sanitary purposes, &c. (4) The extent and value of the ground available for the necessary surface plant, space available for *debris*, sidings, storage room for timber, &c., workmen's and officials' houses, &c. (5) Where the position of the shafts is required to be near a navigable river for transport facilities and good water supply, care should be taken to avoid surface beds of running sands, or gravel, and to also guard against an overflow of the river doing damage to the surface works. Surface beds of sand and gravel add enormously to the cost of sinking, and also to the foundations of the surface buildings.

Underground Conditions.—In many cases the underground conditions requiring consideration are often unknown, or at least they are attended with extreme uncertainty. In unexplored districts some authorities consider it better not to make the first shaft a principal one, but to sink it down, and after proving the number, thickness, and inclination of the seams to decide upon the position of the main winding shaft from the data so obtained. The underground conditions which should be given due consideration are: (1) The estimated life of the colliery. (2) Number, thickness and nature of seams, as to fiery nature and liability to spontaneous combustion. (3) Inclination of strata, and amount of water expected to be given off. (4) The presence, position, course and extent of faults, dykes, washouts, &c. (5) The estimated cost of sinking at different possible sites. (6) Underground wayleave, outstroke, and shaft rents.

Where the prevailing conditions admit, the shafts are sunk in the centre of the royalty, and are placed near together. By this means a large area of work can be quickly opened out, thus giving a quick return on the invested capital; there is an equal distance for the haulage, thus helping to equalise the

load on the engine. The air-ways for a given output are shorter, the ventilation system is simpler, and a saving is effected in the ventilating power. By the centralisation of the shafts economy may be effected, since the surface works and plant are concentrated, less surface room being required. Economy may also be effected in the installation of the necessary plant, power generation and distribution. Shafts are often placed in the centre of the royalty when the seams are horizontal, that is, provided the other conditions are favourable.

In seams which possess a high or fairly high amount of dip, the shafts may be sunk at the lower side of the royalty. The advantage of this procedure lies in the fact that any water which is encountered will naturally drain in that direction, whilst at the same time the haulage may be performed with more ease owing to the assistance of gravity. Sinking shafts in this position accounts for a saving in expensive haulage machinery and pumps. The cost of sinking will be greater than if the shafts had been sunk in the centre of the royalty, owing to the greater depth of the shafts. In some cases the pumping shaft is placed at the lowest point in the royalty, the winding shaft is sunk at any properly convenient situation with regard to haulage and transport facilities, and the upcast shaft sunk at the highest point of the royalty. By the adoption of this method haulage is facilitated, the water drains away and leaves the faces dry. Owing to the downcast being at the lowest point and the upcast at the highest, the true principle of "ascensional ventilation" may be observed.

Where the seam is liable to spontaneous combustion, the shafts may be conveniently situated at the higher side of the royalty, so that if a fire breaks out the workings can be flooded, and the shafts still kept in workable condition. When the fire has been extinguished the workings may be gradually opened out as the water is pumped from the pumping shafts.

The question of wayleave and outstroke is an important one. In many cases the royalty has to be paid to several persons, and as each may extract the payment of wayleaves, *i.e.*, payment for the privilege of bringing coal or other mineral through his property and up the shaft. These are usually paid on the ton of mineral carried, and coupled with the outstroke, the cost per ton may be anything from ¼d. to 1½d. per ton, and shaft rent ¼d. to ¾d. Therefore, it is obviously the better plan to sink the shaft on the largest property as this means a saving of wayleave rent.

The above are the main points to be considered, but of course there are many other points which should have careful consideration before deciding upon the laying off of the shafts. It will be utterly impossible to choose a site which will be suitable to the whole of the existing circumstances, and however well the site is chosen disadvantages will certainly occur.

Indebted to notes taken at a local mining class for part of this answer.

WALTER HEYS, 1, Walter Street, Huncoat, Accrington.

[NOTE.—Far more points have to be considered before laying down the position of proposed shafts than would appear to be the case at first sight. It is absolutely essential that we should be in touch with a railway if mining operations are to be carried on on anything like a large scale. A supply of good water is equally important. We must have room for all surface appliances, such as screens, workshops, engine-houses, offices, and of course sidings. As regards underground an ideal condition of things would be an area of coal in the form of a basin with the shafts sunk at the lowest point, and the coal running under the influence of gravity to the shafts from all parts. This is a state of things which seldom, if ever, actually occurs. It is advisable that the shafts, or at any rate the winding shaft, should be sunk on the largest estate so as to avoid paying wayleave to any other properties on the coal from the largest estate. The shafts should be situated in such a position that the haulage roads may be set out in different directions so as to pass through as few different estates as possible, to reduce wayleave charges.

We believe in sinking shafts to the deep of an estate so that the bulk of the coal can gravitate to the shafts with mechanical power. The drawbacks to this are that our ventilation will probably become more difficult, as rise workings are harder to keep free from gas than dip workings, and also that we shall have deeper shafts. The extra cost for winding will, however, probably be more than compensated for by the saving in haulage expenses.

It will be impossible in practice to obtain all the above mentioned *desiderata;* we shall have to fix the position of our shafts so as to give us the most important of them, at the same time sacrificing the other less important ones.—C.C.M.]

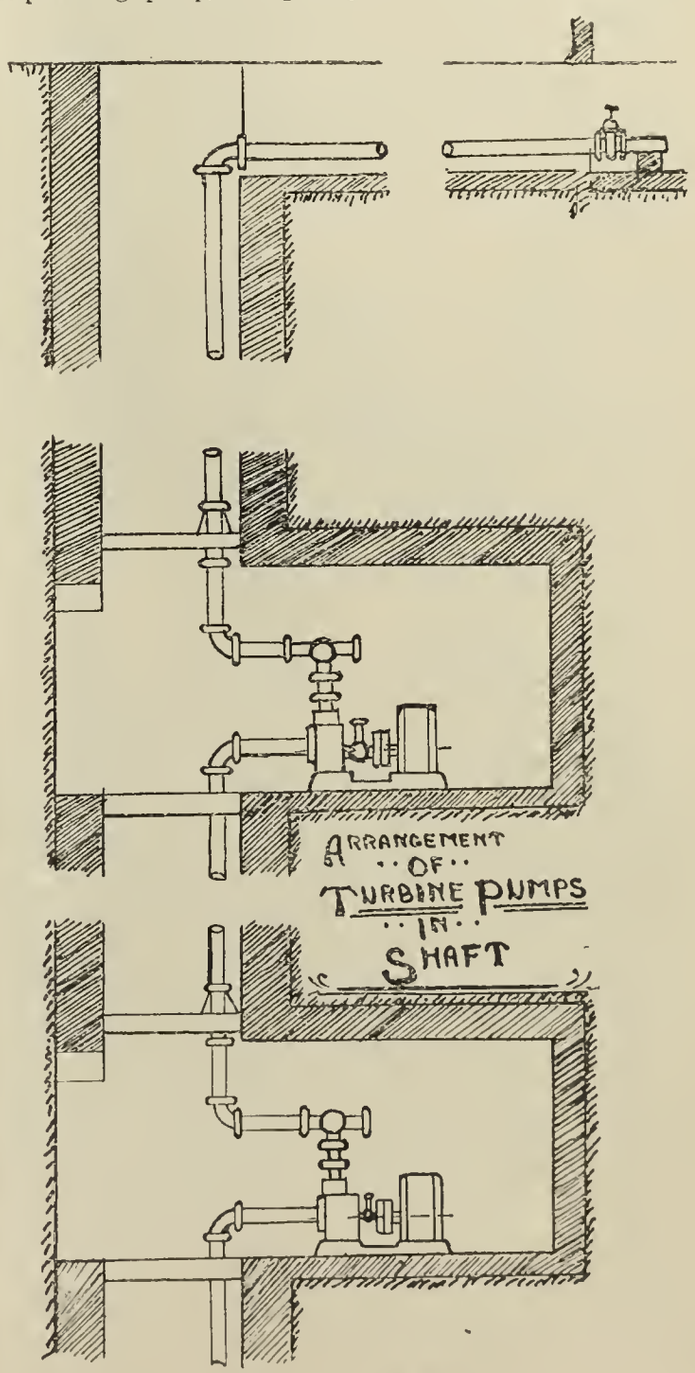
D. Mainwaring, W. Silverwood, R. J. Edwards, F. Hutchinson, W. T. Hughes (*12 marks each*).

Pumping.

Q. 10.—*What advantage is there in having a series of lifts in a shaft instead of a single lift to the surface?*

A.—Turbine pumps, although not suitable for high lifts, are capable of dealing with large quantities of water, therefore to deal with large quantities of water against a great head several of these pumps are installed, and are termed "multi-stage" pumps.

In order to deal with high lifts and so compete with the reciprocating pump, the principle of compounding has been



Illustrating Question 10.

introduced, which is simply the combination of two or more pumps in one in such a manner that the water is finally discharged with the accumulated energy imparted to it at the several stages. Thus if one pump was capable of delivering against a head of 50 feet, two properly combined would deliver against a head of 100 feet, and so on.

The second impeller starts with the added pressure transmitted from the first, and it is similar as if the water had been delivered against a pressure, to the second pump, due to the head to which the first pump would have delivered it.

The advantage of arranging the pumps in a series of lifts, as shown in sketch is that it is possible to so arrange the impellers that one or more may be cut out if required. This is advantageous in regard to sinking, as it meets the requirements of a varying head.

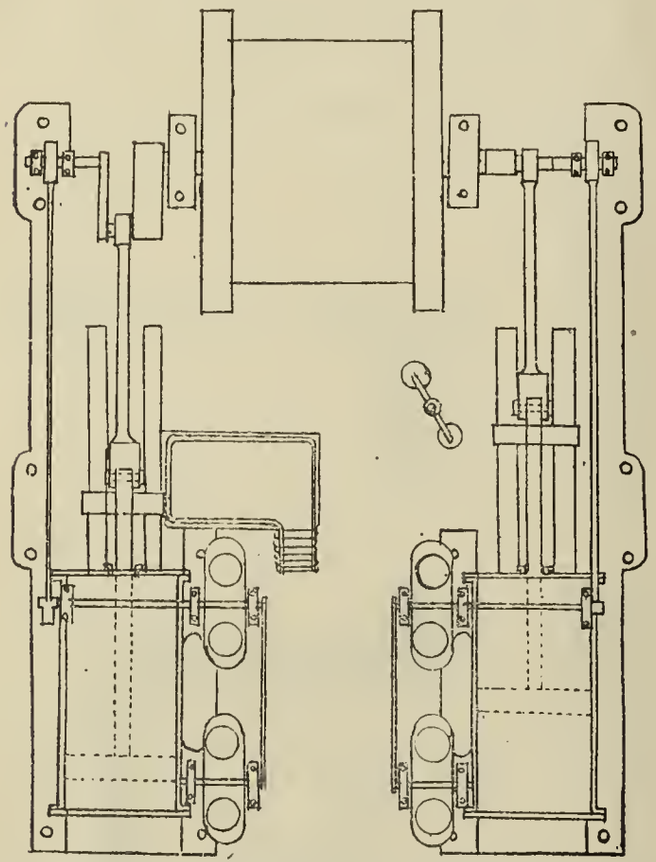


Figure 1, illustrating Question 11.—High Pressure Winding Engine Fitted with Automatic Variable Expansion.

It is also of great advantage where large quantities of water have to be dealt with, as if one large compound pump was used to deliver the water in a single lift to the surface, and this pump went wrong, unless a large lodgment was provided for the water the place would soon be flooded out, and possibly a great deal of expense incurred. By arranging the pumps in a series of lifts therefore, if one pump should break down it is possible to arrange the impellers so that this pump may be cut out until it has been repaired, and thus pumping is carried on as usual without the aid of this pump. By this method of multi-stage pumping large quantities of water have been dealt with, and in one case which the writer has read of, a plant installed in a Spanish silver mine, the pumps were placed 500 feet apart, and as three sets of pumps were employed a continuous column of nearly 1,500 feet was delivered to the surface. There is no lodgment of water at the intermediate stages, the lowest pump delivering immediately into the suction pipe of the second pump, and so on in like manner upwards.

Another advantage of this system of pumping is that little space is required, and as the pumps may be driven by almost any motive power, namely, compressed air, gas, steam, water power, or electricity, they do not require any "special" power to be installed to work them.

Other advantages of the turbine pump are: Small number of working parts, compactness, low first cost, and the minimum of wear and tear. Consequently there is a large amount of saving in cost.

Assisted by BOULTON'S *Practical Coal Mining* for sketch and part answer.

W. T. HUGHES, 103, Wigan Road, Ashton-in-Makerfield.

[NOTE.—With a series of lifts instead of one single lift the total weight of our moving parts will probably be reduced owing to the top portions not being required to be so strong (nor consequently so heavy) as in the case of a single lift. As a consequence less powerful pumping engines will be necessary, and the net result will be a saving in expense. Repairs can no doubt be more easily carried out in the case of several lifts, besides being perhaps not so likely to occur. On the other hand, no doubt more expense will be incurred owing to its being necessary to provide lodge-room for each lift, instead of one only at the bottom.—C.C.M.]
F. Hutchinson, W. Heys, R. J. Edwards (*12 marks each*).

Winding Engines.

Q. 11.—*What kind of engines do you prefer for winding purposes, and why?*

A.—The type of engine I prefer for winding purposes is the simple high pressure engine, fitted with variable expansion worked automatically. Such an engine, used extensively in the Midlands and South Wales at large collieries, and manufactured by Messrs. Thornewill and Warham, of Burton-on-Trent, is shown in *Figure 1*. It has a pair of horizontal cylinders 36 inches diameter, with 6 feet stroke, coupled direct to the

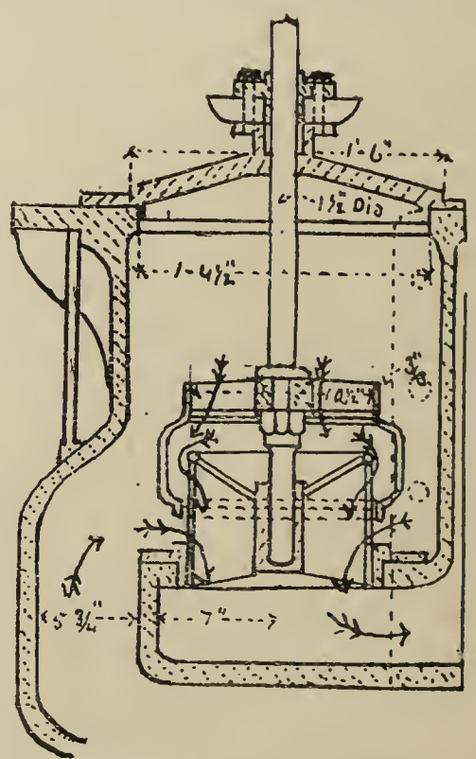


Figure 2, illustrating Question 11.—Section of Valve Chest and Cornish Valve.

drum shaft, one on each side, with cranks set at right angles. Each cylinder has four Cornish valves (see *Figure 2*), two for steam, 10 inches diameter, and two for exhaust, 12 inches diameter. A steam and exhaust valve is placed in each valve box. The eccentrics are worked by drag cranks, and placed on the opposite side of the cylinder to the valves. The motion is carried by a weigh bar, passing over the top of the cylinder, to which is attached the rocking lever or tappet of the forward valve box, that of the rear being swung from this shaft by means

of a drag link. The spindles of the valves are fitted with dash-pots at their upper ends, and those of the exhaust valves with cylindrical weights. The automatic expansion gear allows the wind to be commenced with full steam for a few revolutions until the resistance of the load has been overcome and a maximum speed attained. At this point the full power is no longer required, the expansion gear comes into operation, and the engines work expansively until the speed falls towards the end of the wind. Connected directly with the cranks is the winding drum, cylindrical, 20 feet diameter, 8 feet wide, having three sets of cast-iron discs and segments united by wrought-iron arms, twelve to a set, there being six segments in each circle. The three circles of segments are riveted together by $\frac{5}{16}$ inch steel plates, and 3-inch oak lagging is bolted to the plates. Each of the outer circles forms a brake ring acted upon by a steam brake on one side, and foot brake on the other. The indicator which shows the position of the cages in the shaft is worked off the crank shaft. Alongside one of the cylinders is placed a lever for working the throttle valve for admitting or stopping entry of steam to the cylinder, a lever for working the reversing gear, a lever for regulating the steam brake, and a foot lever for working the foot brake attached to the drum.

My reasons for preferring this type of engine are as follows :—

The work that winding engines have to perform is very different from that required of most engines. They are continually stopping and starting, and both load and speed vary at each stroke ; whilst in some cases the total mass set in motion is enormous. For all these reasons it is imperative that winding engines should be built with a view to strength, simplicity and handiness rather than economy in the use of steam.

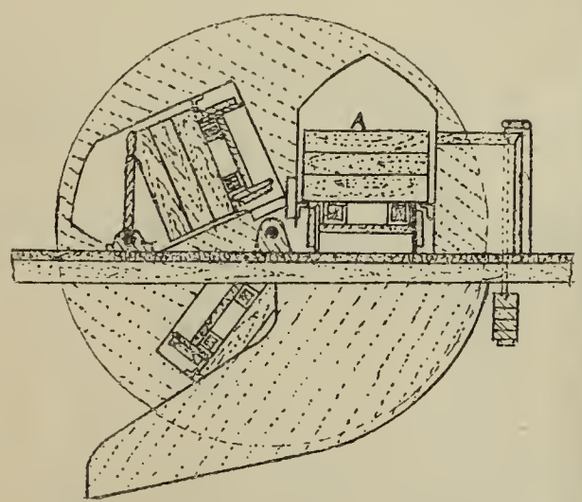


Figure 1, Heenan's Gravity Tippler.

Illustrating Question 12.

It is quite true that the compound engine has its advocates, and in some modern plants has been adopted. Those in its favour urge that in a simple engine the application of expansion leads to violent shocks upon the rope and drum, which materially increase the danger of accident, and are responsible for the trouble so frequently experienced with winding drums, and that with a properly designed compound expansion is extended and the strains are more equable. It is certain that the more equable the strains the lighter the drum can be and the dead weight to be accelerated at the beginning of the wind, which is an important factor in the power of the engine, or the speed of winding can be reduced.

Against these arguments can be advanced that the introduction of low pressure turbines affords a means of utilising the exhaust steam from an ordinary winding engine, and thus enables the high pressure engines to present such advantage in the way of simplicity that they can be recommended to hold their own even with the best types of compound engines.

Indebted to *Modern Mining Practice* by G. M. Bailes for assistance in compiling this answer.

Fred Hutchinson, 27, Longfield Road, St. Helens Road, Bolton.

[Note.—Undoubtedly nine people out of ten will be found to prefer the well-known horizontal reciprocating form of winding engines, with Cornish and Corless valves. There will possibly be less agreement as to whether the drum shall be cylindrical or conical, or a combination of both principles. The last-named, if properly built up, is probably the best, and goes a good way in the direction of counterbalancing.

It must be admitted that there are many vertical winding engines in different parts of the country doing work little, if any, inferior to that done by horizontal ones, but vertical engines adopted owing to restricted area of ground available for the engine house. Again, there are several electrically-driven winding engines at work at present, giving perfectly satisfactory results, but on the whole the man who selects for his winding engines a pair of horizontal reciprocating engines is on firm ground. In some cases we must not omit to mention compound condensing winding engines have been adopted, but we are not quite sure but that such engines are best adapted for continuous running engines, such as fan and endless rope haulage engines.—C.C.M.]

W. T. Hughes, W. Heys (*12 marks each*).

Self-Acting Tipplers.

Q. 12.—*Give a general description of some different forms of self-acting tipplers for emptying hutches.*

A.—Heenan and Froude's Patent Gravity Tippler (see *Figure 1*). This is a tippler which allows the tub to enter it at one end and pass out at the other. It is a good example of the gravity

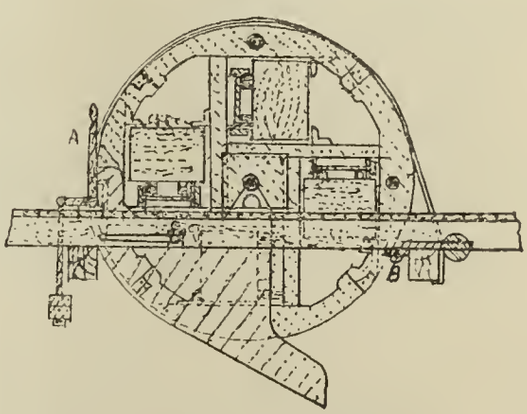


Figure 2, Wood's Gravity Tippler.

Illustrating Question 12.

class, and is capable of dealing with large outputs. It consists of two mild steel rings, built up of channel steel and jointed to the centre boss by means of channel steel of the same section, and strongly held together by plates. The end rings are joined together by side plates $\frac{1}{2}$-inch thick, and also by angle-irons, forming the rails for the tubs. The whole is suspended on a strong shaft 4 inches diameter, mounted on two bearings. It holds three separate tubs, which rotate in a sort of squirrel cage, the revolution being caused by the weight of the loaded tub (*A*, *Figure 1*). When at rest the tippler is held by two powerful brakes, which pass round the periphery of the two end rings. These tipplers if desired can be made with an automatic stop, but with a good attendant this is unnecessary. They may also be fitted with an ingenious arrangement of automatic claws which grip the buffers of the tubs and hold them in position ; they can also be had to hold four tubs if required.

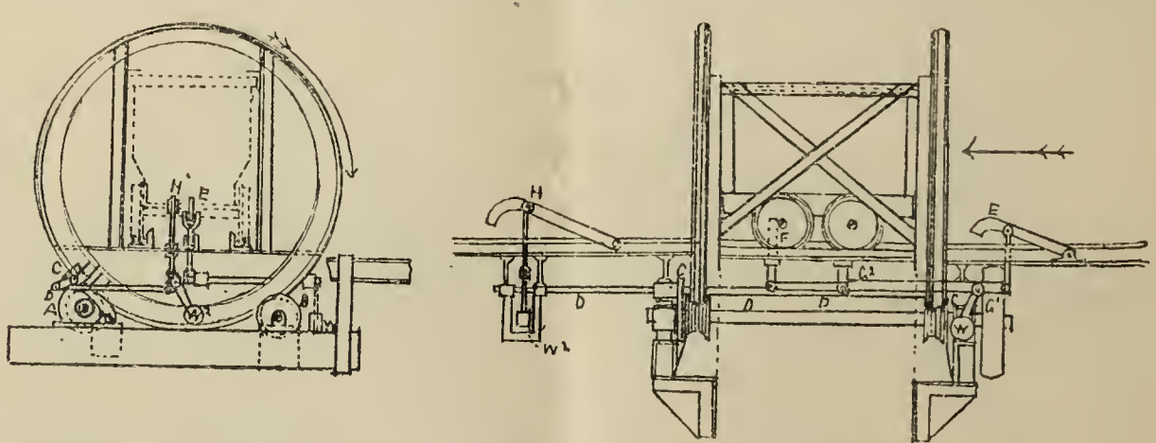
The Gravity Tippler, by John Wood and Sons, Wigan, is shown in *Figure 2*. This is an ingenious contrivance which has been extensively applied to modern installations. It is of the four box type, and is similar in operation to the one described above. The brake strap, which is controlled by the hand lever

and the weight *A*, serves to control the starting and stopping of the tippler, and to regulate the speed with which the coal is unloaded. The stop-piece *B*, which is operated by the pedal and weight, ensures that the tippler shall stop automatically at the right place. Both the above-mentioned types are self-acting, simple in construction, and well adapted for dealing with large quantities of coal, especially soft coal, as there is "practically no fall, and breakage is reduced to a minimum."

Cook and Hobson's Patent Automatic Tippler is one which works automatically on a slightly different principle to the above-mentioned types. (See *Figure 3*). *A* and *B* are two friction rollers. Two of the friction rollers marked *A* in the sketch are keyed on to the driving shaft, and the steel rings forming the ends of the tippler itself fit into grooves cut in these rollers so that whenever they come in contact with the rollers they are driven forward in the direction of arrow. The rollers on the other side *B* are loose rollers to support the rings, and allow them to turn freely. When at rest the rings are supported on one side by the loose rollers *B*, and on the other side by a pair of cast-steel brackets marked *C*, one under each ring. These brackets are supported by the eccentric shaft *D*, so that the rings are $\frac{1}{8}$-inch clear of the friction wheels *A*, when the tippler is at rest. As the full tub enters the tippler it releases the empty one, and is in turn held fast; the front axle also depresses the lever *E*, which works the stopper *F*, through the two levers G^1 and G^2. The lever G^1 works on a pivot under the platform and carries a weight *W*, which tends to raise *E*. The other lever G^2 is carried by the revolving part of the tippler, and the searfed end of it overlaps the end of

OTTER HOUNDS IMPRISONED IN A DRIFT.

The Felling Colliery Reseue Brigade had a most unusual call made on them, according to the *Newcastle Chronicle*. A telephone message was received from Mr. W. A. Hoyle, master of the Northern Counties Otter Hounds, asking if the brigade could go to Lord Bolton's estate, at Wensleydale, as some hounds had been out there a week ago, and went full cry into a lead mine's drift. The drift is full of carbonic acid gas, which is, of course, highly dangerous to life. The otter very soon came out, and so did some of the dogs, but eight of the latter were left in. As the water coming from the drift supplies the district for drinking purposes, there was naturally a great deal of anxiety displayed as to recovering the bodies of the dogs for fear of putrefaction and the contamination of the water. The brigade party on arrival at the mine set to work to get out the dogs. After some difficulty they managed to penetrate the drift to about 250 yards, and found, much to their surprise, all the dogs alive. It appears that the animals had managed to rush through the carbonic acid gas, and to climb on a heap of *debris*, which had formed a mound. Water was running over, and the dogs had found clear and pure air. Apparently the hounds' instinct had caused them to choose this place, and they had not attempted to travel away from it. The incident is considered a most extraordinary one, for the dogs had been imprisoned in the drift for a full week. When released they were in good condition, although somewhat thin as the result of their privations. The animals were restored to their master, who was profuse in his thanks to the rescue party.



Illustrating Question 12.—Figure 3 and 4, Cook and Hobson's Patent Automatic Tippler.

G^1 when the tippler is at rest. A spiral spring under the outer end of G^2 keeps it and the stopper in the position shown.

After the stopper *F* is depressed by the full tub, the latter pushes out the empty tub, keeping the stopper down until the empty tub is clear. After the last axle of the empty tub has passed over the stopper *F*, the full tub has advanced so far as to relieve the lever *E*, with the result that the stopper resumes its position and keeps the full tub in its place. The empty tub being clear of the tippler ring strikes the lever *H*, which by a system of connected levers works the eccentric shaft *D*, and allows the buckets *C* to fall, thus bringing the rings into contact with the friction wheels *A*, and immediately starting the tippler.

The lever *H* is connected to a weigh shaft which carries a counterweight *W*, as shown. This causes the lever *H* to rise and the brackets *C* to resume their original position as soon as the empty tub has passed. When the tippler has returned to the upright position the projections on the sides of the rings run upon to the bracket *C*, and so lift the rings clear of the friction wheels and the tippler is stopped.

Indebted to Boulton's and Tonge's *Mining* for assistance in compiling this answer.

Fred Hutchinson, 27, Longfield Road, St. Helens Road, Bolton.

W. Heys, D. Mainwaring, H. P. Smith (*12 marks each*).

New Coal Seam in Cumberland.

Important discoveries of coal and other minerals have been made in the Longtown district of Cumberland, and operations are to be commenced immediately to develop the working. Concessions have been granted by Sir Richard Graham to a local syndicate for the purpose of developing the minerals on the Netherby estate. The result of the sinkings has inspired the prospectors. Coal of good quality is said to be in abundance, and various other minerals have been found, while freestone is plentiful. The discovery is of immense importance, to the Border Counties especially.

Watering Roadways.

An invention by William Tonks, of Blyth, having for its object the watering of roadways and laying dust in mines, comprises the combination of a liquid tank mounted on a wheeled carriage or bogie, a chamber or recess provided below the tank and closed at the ends and open at the sides, a horizontally disposed rotary distributor or spreading disc arranged within the chamber and adapted to be rotated from the axles of the vehicle, and means for controlling the flow of liquid from the tank to distributor or disc. In the specification it is explained that the apparatus may be arranged to discharge, distribute or spread salt or other substance instead of or as well as liquid.

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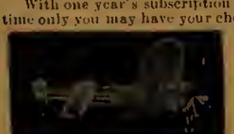

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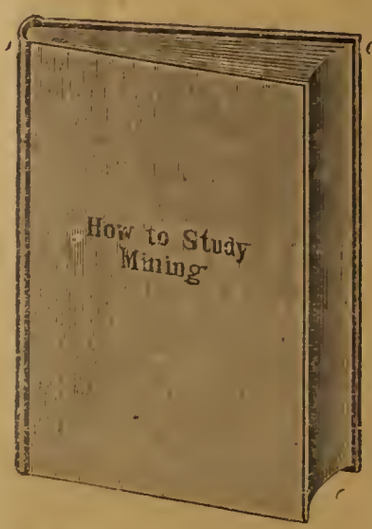

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NEWS AND NOTES.

Cadeby Colliery Explosion.

The inquest on the victims of the Cadeby Colliery disaster was concluded at Cadeby on the 24th ult. Mr. Frank Allen, the District Coroner, said that the death roll numbered 87, and it was believed that 14 bodies were still in the mine. The jury's business was to inquire into the cause of death. He had been in communication with the Home Secretary, who wrote that he did not intend in any way to limit that inquiry, but he had decided to order an inquiry under the Coal Mines Act. The explosion, continued the Coroner, was supposed to have originated from a gob-fire.—Several witnesses gave evidence as to the condition of the pit, and described incidents connected with the disaster. Harry Hulley, a deputy, who was with the rescue party, said the explosion had evidently been greatest in force at 64 gate, down the crossgate, and into 16 level. Most of the bodies were found there in a pile. They were burnt. In reply to a question he said that a few days before the explosion he told Mr. Pickering he thought there was a fire in the pit.—Percy Mugatroyd, a filler, who was with the rescue party, said he found a watch hung up near some dead bodies. It had stopped at ten minutes past one. Describing the second explosion, he said the first shock was like firing a shot, and then there was a great row. It was like a fierce blasting. He saw no flame. In a short time the crossgates were all filled with dust, smoke, and after-damp. So thick was the dust that he could hardly see the light of his electric lamp. The party flung themselves on their faces. Witness had an oxygen tube in his mouth, and to that he attributed his preservation. He ran towards the crossgates, but stumbling over a girder he discovered he was going in the wrong direction. Returning, he fell over the bodies of Mr. Pickering and the other members of his party, which were all over the way. He came to another fall, but could not get over it. He tried to telephone for assistance. He proceeded over the fall through a way that had been made for him, and met Mr. Whitty, to whom he reported the position of the rescue party.—Mr. H. Whitty, agent for the colliery, describing the scene after the second explosion, said that they found the bodies of Mr. Pickering, Mr. Douglas Chambers, Mr. Berry, Mr. Hewitt, and Farmery in a heap. On the following night there was a further explosion.—Mr. J. R. R. Wilson, Acting Chief Inspector of Mines for the district, said that Mr. Pickering rang him up on the telephone on the morning of the disaster, saying he had to meet the King in Elsecar, and asking witness to go to Cadeby. At that time it was understood the explosion was not serious. When witness arrived at Cadeby, however, he found Mr. Pickering already there. With two other Government inspectors witness descended the mine, and had only been down a short time when the heard a sudden blast of return air. It was the second explosion, and they started to return to the main plane as quickly as possible. They had to crawl over a big fall on the way. They came across a group of nine men, two of whom were alive. Mr. Hudspeth returned and gave them water. In the nineteenth crossgate they found 22 bodies lying in all positions.—The Coroner, reviewing the evidence, said that the death of two managers and three inspectors had made it rather more difficult to present the story of the disaster. When the stoppings were taken out and the other fourteen bodies recovered, a further inquiry would have to be held. There was no doubt the cause of the explosion was coal dust.—The jury returned a verdict of "Accidental death arising from gas explosion."

Fire-Damp in Mines.

At the meeting on the 18th ult. of the South Wales Institute of Engineers, the paper, "Notes on the Analysis of Mine Air conducted at the Lewis Merthyr Consolidated Collieries," by Messrs. J. W. Hutchinson and Edgar C. Evans, was under discussion. In a letter explaining that attendance at a meeting at the Home Office prevented his presence at Cardiff, Dr. Haldane, F.R.S., who incidentally is the inventor of an important apparatus for the detection of minute quantities of methane in the air of mines, stated that the authors of the paper showed (for the first time, so far as he was aware) that even in a Welsh steam-coal pit, with fire-damp issuing directly from the face in large quantities, changes in barometric pressure, as well as work at the face, have a distinct effect on the issue of fire-damp. In view of the necessity created by the new Mines Act of colliery firemen being able to interpret the cap on the lamp flame in percentages, Professor Galloway made the interesting announcement that he examined about 600 firemen last month, and he was astonished to find that most of them were able to tell within half per cent. the quantity of fire-damp indicated by the size of the cap.—Dr. Atkinson suggested that the "personal equation" was a factor always to be reckoned with. He had known men who could see a cap on the lamp's flame when he could not, and, on the other hand, he had met men who could not see a cap when he saw it quite plainly.—The paper was deemed to be of such importance that, notwithstanding the protracted debate of the afternoon, it was decided to adjourn the discussion to the September meeting, which will be held at Swansea.

Sub-Inspector of Mines.

The Home Secretary is prepared to consider applications in connection with the appointment of fifteen sub-inspectors of mines and quarries. Each sub-inspector will be appointed for and attached to one of the six divisions into which the United Kingdom will be ultimately divided for the purposes of inspection. The salary of sub-inspectors is £150, rising by £5 a year to £200 a year. The appointment will be by limited competition, that is to say, a certain number of candidates, who appear, after careful inquiry, to possess the best qualifications in training and experience for the work, will be selected from the total number of applicants in the division, and they will be nominated to compete among themselves for the appointments in that division. Nominations are given only by the Home Secretary, on the advice of the Board for Mining Examinations, who will consider all applications impartially on their merits. No recommendations or testimonials are considered unless based on personal knowledge of the candidate's character and attainments. Candidates are therefore particularly advised in their own interest not to seek political or social influence, which will prejudice rather than assist the candidature. No person can be nominated as a candidate for a sub-inspectorship of mines who has not had at least five years' practical experience of general underground work in coal (in the case of candidates for the Cleveland appointment substitute "stratified ironstone" for "coal") mines, and who is not engaged in such work at the time of nomination. He must also hold a first class or second class certificate under the Coal Mines Regulation Acts. Other things being equal, preference will be given to candidates holding first class certificates. Candidates for sub-inspectorships of quarries must have had at least five years' experience of general work in quarrying, and must be engaged in quarrying work at the time of nomination. Applications for nomination must be made to the Private Secretary, Home Office, London, before the 15th August next.

EXPLOSIVES ACCIDENTS.

The annual report for the year 1911 of H.M. Inspectors of Explosives has been issued, and it may be appropriate to note the following excerpts :—

Prematures and Failing to Get Away from the Shot-Hole.—There were 20 accidents due to the above, causing injury to 21 persons. Of these accidents a very excessive number of prematures was due to shots known to have been ignited by squibs, the number of such accidents being 12, responsible for injury to 12 persons.

Firing by Electricity when Persons are at the Shot-Hole.—Fifteen accidents occurred with electric firing, resulting in three deaths and injuries to 13 persons. All but one of these accidents occurred in collieries where permitted explosives were used. Of these 14 accidents, one was caused by the accidental contact of the firing cable with the terminals of the battery. In another case the shot-firer was connecting up his cable to the detonator leads when his exploder is supposed to have been overturned by a hose which a man was dragging along. This caused the handle of the exploder to revolve sufficiently to fire the shot, the press button spring having been found to be weak. Two accidents were caused by the shot-firer allowing another man to have charge of the battery while he himself was at the shot-hole, and one by the injured man leaving the handle on his exploder while he returned to a miss-fired shot, when a lad turned the handle and fired the shot.

The remaining nine accidents were due to the shot-firer firing the shots before persons at the shot-hole had taken cover. Few if any of the casualties would have occurred had the precautions laid down in the Explosives in Coal Mines Order been observed.

The one accident with non-permitted explosives was caused by the fireman firing a shot while persons were in the vicinity.

Not taking Proper Cover.—Under the heading "Not taking Proper Cover" are included those accidents which occur to men in the neighbourhood who have exposed themselves, either unknowingly or from lack of judgment, to the *debris* projected by a shot. We have not included accidents to persons at a considerable distance from the shot-hole. Ninety-nine accidents were recorded this year. Nine of these arose from "blow-throughs," that is to say, the casualty occurred from material being projected from the back of the shot-hole into another working-place or road. For some reason unknown to us the number of these accidents is considerably greater than last year.

Hang-Fires and Returning Too Soon to Shot-Holes.—Forty-one accidents have been recorded under the heading of "hang-fires." In this group are included nine cases in which more than one shot was to be fired in or near a working-place and the miners, hearing the explosion of a charge, returned to their working-places. Nine hang-fires occurred where squibs were employed to ignite the shot.

Three accidents occurred when firing by electricity. In two cases the cable had been disconnected when the shots exploded, and in one of these the shot-firer heard the detonator explode. He took two colliers back to prepare another hole when the explosion took place four minutes after the attempt to fire the shot.

Ramming or Stemming the Charge.—There were 33 accidents in ramming or stemming the charge, causing three deaths and injury to 42 persons. In ramming charges into a bore-hole there must always be some danger, and it cannot be too strongly urged that this operation should be carried out with the least possible exercise of force ; but there can be but little doubt that in all these cases undue force was applied. The best method of preventing this class of accident is to ensure that the men are not allowed to use drills which have become much worn, and also that the diameter of the cartridge is such as to give good clearance even with a slightly worn drill. It is most important that the cartridge shall not stick in the bore-hole, as if it does the miner is quite certain to use sufficient force to get it to the bottom of the hole, as to fire the charge half-way down the hole would entail the loss of half his work. We have suggested to various members of the explosives trade the advisability of standardising the diameters of the cartridges supplied by them to the mines. In the manufacture of blasting cartridges some little difference of practice obtains ; some firms considering that a 1-inch cartridge is one which has been squirted through a 1-inch die, others making an allowance for the paper wrappers. Consequently, in a mine in which the men had been in the habit of using a cartridge made by one of the latter firms they would find the drills a shade too small to work with the cartridge of the former's production. Our proposal has been that cartridges should be made exclusively of certain standard "over-all" diameters (22, 33, and 44 millimetres have been suggested), and that these cartridges should be known as sizes 2, 3, 4, &c., and that intermediate sizes should not be made after a given date. This would cause a slight expense in altering drills at some mines, but we learn that the cost of this in a certain large mine was only about £7, so that this should form no insuperable obstacle. After the care which should be devoted to the drills, the other points which require attention are (*i*) to avoid bunching the cartridges (*i.e.*, tying two or three together or otherwise inserting several at the same time) ; (*ii*) the use of wooden rammers ; (*iii*) the thorough softening of all nitro-glycerine explosives before use. Even with all the above precautions, however, the use of undue force may always cause an accident. A general impression seems to exist that, at any rate in the case of gunpowder, no amount of ill-treatment with wooden, or even with copper tools, can possibly lead to danger, whereas, as a matter of fact, sufficient heat to ignite gunpowder may without much difficulty be produced by the contact of two particles of flint or other hard substance without the intervention of iron or steel—the absence of which therefore merely *reduces* the risk.

Sparks, Flames, &c.—Under the heading of "Sparks, Flames, &c." are grouped all accidents which were caused by explosive being ignited by a naked flame or spark in the course of blasting operations. There were 95 such accidents during the past year, and in every case but one gunpowder was the explosive involved. 109 persons were injured by these accidents, which were, in many cases, due to non-conformity with the usual regulation enjoining the removal of the candle or lamp from the cap before preparing a charge. In two instances the accident may have been caused by men smoking. This type of accident shows a very marked increase during the past year.

Boring into Unexploded Charges.—Twelve accidents have been recorded under the heading of "Boring into unexploded charges," which includes those accidents where, in attempting to bore a second hole near a miss-fire, the drill has accidentally struck the unexploded charge, and those where boring was carried out in an old hole believed not to contain explosive. These accidents differ from those where, contrary to rules, attempts are made to bore out miss-fired shots.

Striking Unexploded Charges in Removing Debris.—Of the 13 accidents caused by striking charges or portions of charges which have not exploded, no less than seven were caused by explosives containing a considerable proportion of nitro-glycerine. These are caused by miss-fires and by partial ignitions (portions of the charge remaining in the mineral, their presence being unsuspected) or by an insufficient search being made in the case of shots which are known to have missed. A fertile source of such miss-fires and incomplete detonations is to be found in the use during cold weather of explosives which have not been softened. Of the five remaining accidents, none of which were fatal, two arose from detonators being struck and one from the striking of a charge of an ammonium nitrate explosive which did not contain a detonator.

With a view to throwing light on the occurrence of accidents under the three headings of "Ramming, &c.," "Boring into Unexploded Charges," and "Striking Unexploded Charges in the *Debris*," we again give a table showing the number of accidents which occurred during each month. Only those in which an explosive containing over 10 per cent. of nitro-glycerine was involved are here shown. This table shows in a most marked way that the bulk of these accidents occur in the first three months of the year. They disappear almost entirely during the summer, and show a tendency to recur as the weather gets colder again. It is found that during the first three months of the year explosives of this class are more likely to be frozen than at any other time, as it takes some time for the explosive to become frozen in the magazines ; indeed, it is more often that it becomes frozen during conveyance than during storage. These facts taken together render it more than probable that to the employment of frozen explosive may be attributed

the great majority of these accidents. It will be seen that during the past eleven years 365 accidents have occurred during the winter months December to May, whilst during the remaining six months the number was only 124.

Cause.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ramming or Stemming the Charge	3	3	4	3	1	1	—	—	—	—	1	1
Boring into Unexploded Charges	1	2	1	—	1	—	2	—	1	—	—	2
Striking Unexploded Charges in Removing *Debris* ..	2	2	1	—	—	—	1	—	—	—	—	1
Total of above Causes ..	6	7	6	3	2	1	3	—	1	—	1	4
Total Number in past Eleven Years	68	76	83	51	34	23	24	12	20	17	28	53

These figures are such as to afford some reason for thinking that the efforts which have been made to induce users of this class of explosives to make a regular habit of using a warming pan during the winter and spring months are beginning to be effectual. We have been encouraging magazine owners to adopt some method of heating their magazines, and already some have been so fitted. The best method seems to be the use of hot water circulating pipes heated by a slow combustion stove at some little distance from the magazine, and adapted for burning coke or anthracite. It would appear to be a fact that explosives which have never been allowed to become hard by solidification of the nitro-glycerine do not show so much tendency to freeze as those which have been frozen once and subsequently thawed. Even so, however, any measure of warming magazines can only be regarded as a palliative for the evil, the true remedy for which is the regular and proper use of warming pans by the users.

Explosive in Coal.—Six accidents were due to the presence of explosive in coal. Three of these were in private houses all in the same street and within a few days of one another, but fortunately no one was injured by them. Examination of the coal disclosed the presence of gunpowder cartridges among it.

The most serious accident occurred in a stove in a drill hall. By it two sergeants were killed and another man was injured. One of us investigated this accident, and concluded that it was undoubtedly due to the explosion of a cartridge of blasting explosive (probably gelignite) in the coal. In the fifth case an explosion occurred in a smith's fire, while the sixth was caused by a detonator exploding while coal was being screened at the colliery.

THE "PP" SAFETY SHOT-FIRING APPLIANCES.

At a demonstration held at the Westminster Palace Hotel, London, Sir Alfred Mond, Bart., M.P., presiding, the following paper was read by Mr. William Pryse, one of the inventors of the Price and Pryse method of safety shot-firing appliances for mines of all kinds, quarries, &c. :—

"My co-inventor and I are very pleased indeed to have this opportunity of addressing you on the subject of our invention. Despite very stringent rules and regulations, there were, last year, no less than 38 deaths and 503 more or less serious accidents. I assert, most emphatically, that our invention makes shot-firing and the handling of detonators absolutely safe and casualties impossible. The dangerous and costly process of drilling another hole alongside in case of mis-fire is entirely done away with. There is no time lost in searching for unexploded detonators, with its attendant dangers. No loss of time or output due to mis-fires will occur if our system is adopted. By the adoption of our system it is impossible for any person other than the appointed shot-firer for the district in the mine to charge or stem a shot-hole. If, after charging a number of holes in a district in a mine, the examiner finds that the conditions are such as to prohibit shot-firing, the detonators can be removed with perfect safety and re-inserted when conditions are normal. Many means have been adopted for the purpose of making detonators, as far as possible, safe to handle, and certain of firing, such as small coils on the firing wires inside the detonators, cementing, and so forth, but still the mis-fires continue to occur, and any strain applied to the wires is transmitted to the internal composition of the detonators. We have worked on an entirely different line, and have invented appliances and a system of using these appliances whereby mis-fires, given a perfect detonator, become impossible; but should mis-fires occur, through faulty detonators or connections, the detonator can be, from a place of safety, immediately withdrawn from the shot-hole, the leads being connected to the firing cables in a suitable manner for so doing. After withdrawal the hole can be approached, and a fresh detonator inserted, the whole operation taking not more than three minutes, as we shall presently show. Or, if preferable, the detonator may be withdrawn, and the hole left until the next day, when a fresh detonator may be inserted. Taking again the case where an outburst or accumulation of gas is found after the hole has been charged. Instead of leaving the detonotor in the mine, with its attendant dangers due to pressure or movement of the roof, &c., the detonator may be withdrawn and the firing of the hole left until the outburst or accumulation of gas has been cleared.

"Our invention consists of :—

"(1) 'A detonator shield.' This is a casing with perforations to allow direct contact between the gases caused by detonation and the explosive used. Inside this casing is placed the detonator, and at a distance of a $\frac{1}{4}$ to $\frac{1}{2}$ inch from its base, a knot is made on the wires. This knot, when drawn taut against the base of the shield, prevents any strain applied to the wires being transmitted to the internal composition, and, in addition, makes it impossible for the wires and detonator to become detached or separated from one another. We have, moreover, an alternative method of attaching the wires to the shield which does not require a knot. The shield also protects the detonators from friction or shock when inserting or withdrawing.

"(2) Our appliance for inserting the shields and detonators, and suitably stemming the hole to permit of withdrawal, consists of a length of copper tube, graduated on the outside, for measuring the depth of the hole. This is provided with a suitable handle and an internal copper rod with a loose spike at one end, attached in a convenient manner, and locking arrangements at the other end, for securing the various parts, which together form a complete tool with its own special use.

"Before giving you the demonstration of the use of our shields and appliances, I propose to tell you the result of a most severe test which was put to us at the Garn Goch Colliery of Messrs. Glasbrook Brothers, Ltd., at Gorseinon, near Swansea, on Friday, June 21st last :—

"A shot-hole was drilled in solid rock, with equal resistance all round; this bore-hole was charged with 2oz. of Samsonite, and we withdrew the detonator the first time and re-inserted it. Then, following us, the officials of the mine inserted and withdrew detonators six times—each time a different detonator; the eighth time again the detonator was inserted, and we fired the shot and broke ground, despite the fact that the officials of the mine did not expect ground to be broken owing to the small quantity of explosive used. The officials were extremely surprised, as before we fired they stated they did not expect ground to be broken, nor did they want it done."

LANCASHIRE COLLIERY DEVELOPMENTS.

It is announced that important and costly colliery developments are now proceeding in South Lancashire. The Pilkington Colliery Company, who are allied with the Clifton and Kearsley Coal Company, are opening half a dozen mines at their extensive new collieries at Astley Green, nine miles west of Manchester. The Tyldesley Coal Company, the Westleigh Colliery Company, Messrs. Speakman and Astley, and the Tyldesley Coal Company are opening seven or eight additional mines in Tydlesley, Astley, Bedford, and West Leigh localities. Altogether nearly a score of new Lancashire mines are being opened out.

MINE GASES AND GAS TESTING.

By M.E.

[A Series of Articles specially arranged for Firemen, Deputies, or Examiners.]

No. 11.—Explosives.

That there are risks attached to the use of mining explosives does not require to be laboured.

The most obvious of these risks are those of premature explosion, and the possible ignition of fire-damp or coal dust. In addition to these, there is with certain types of explosive an imminent risk of accident arising from the nature of the fumes and gases produced by shot-firing—a risk not well understood by shot-firers and seldom guarded against.

Owing to these risks it is very desirable that all shot-firers and deputies should have a clear conception of the nature of modern explosives, and the manner of their action, in addition to a good knowledge of the statutory requirements of the Explosives Order.

The principle of the use and action of a mining explosive is exceedingly simple. It is used as a convenient means of suddenly applying a large amount of force at a suitable and predetermined point or place in coal or other strata requiring to be broken down.

This force is the result of chemical action set up in the substance of the explosive by a spark or by detonation. The chemical action is of such a nature and acts so rapidly that the solid or plastic explosive substance is, in an instant, converted to gaseous material, which at ordinary temperature and pressure would occupy a volume hundreds of times greater than the volume of the solid explosive from which it has been formed.

Until the walls of the shot-hole are ruptured the gases so produced cannot expand as fast as they are developed, consequently the pressure behind the stemming increases very rapidly, and continues to do so until it has reached a magnitude sufficient to overcome the resistance due to the burden of the shot. As a rule rupture of the shot-hole occurs in a fraction of a second after ignition.

In addition to the high pressure, the gases produced have, at the time of their formation, an exceedingly high temperature. This may be from 3000° to 4000° Fah., which it will be observed is well above the ignition point of fire-damp.

In some cases the gases produced by explosives are decidedly poisonous. Thus in the production of mechanical force by the use of explosives the creation of a high temperature, and the generation of a considerable volume of deleterious gases, are inevitably involved in the operation, giving rise thereby to the possible ignition of fire-damp or coal dust, and the possible production of poisoning effects.

Mining or Blasting Powder.—This is sometimes spoken of as gunpowder, but its explosive properties were known centuries before the invention of guns. It consists of a mechanical mixture of charcoal (carbon), sulphur, and saltpetre (nitre or potassium nitrate). The common British practice is to mix fifteen parts of charcoal, ten parts of sulphur, and seventy-five parts of nitre.

Naturally these substances are solids, and previous to mixing have each to be passed through a grinding mill. The fine powders produced by the mill are mixed in the proper proportions, so as to bring the particles of the various ingredients in contact with each other. After mixing they are compressed into a cake, which is afterwards broken down to form "meal powder" from which the common granular or compressed powder is made.

The potassium nitrate serves as an oxygen carrier for the carbon and sulphur. On the application of a spark, or other source of heat greater than 500° Fah., free oxygen is given off readily by the nitre. This combines rapidly with the carbon and the sulphur grains, and gives rise to the high temperature gaseous products already referred to.

Unfortunately the explosion of blasting powder also results in the formation of a certain amount of granular solid matter. This is usually ejected from the shot in the form of glowing white hot particles which are sufficiently hot to ignite fire-damp or coal dust.

As some of the gaseous products of explosion are inflammable, these are sometimes ignited by the shot or its solid products, and burn for a brief period as a huge bluish flame.

The solid matter produced is nearly equal in weight to that of the gaseous matter. It is somewhat difficult to ascertain accurately the percentage composition of this gaseous matter, but as a rule the chief gases produced are carbon dioxide, carbon monoxide, nitrogen, and sulphuretted hydrogen, with small quantities of other gases.

The carbon monoxide and sulphuretted hydrogen resulting from powder shots are both explosive and poisonous, and may therefore give trouble unless immediately diluted with an ample supply of air. It is estimated that one pound of ordinary blasting powder will produce from 5 to 8 cubic feet of explosive and poisonous gases.

Permitted Explosives.—Owing to the ease with which fire-damp and coal dust may be ignited by shots of blasting powder, this Explosive is now prohibited in all coal mines in which inflammable gas has been found within the previous three months in such quantity as to be indicative of danger, and in all mines that are dry and dusty.

In such mines no explosive may be used other than of a kind the use of which has been sanctioned by the Home Secretary. Explosives receiving this sanction are spoken of as "Permitted Explosives." Reference should be made on these matters to the Explosives Order, 1912. (See pp. 558–9, No. 24, Vol. 22, of *The Science and Art of Mining.*)

Before being placed on the schedule of "permitted explosives" (the first Schedule of the Explosives Order), an explosive is subjected to a severe test by experts acting under the direction of the Home Secretary.

The principle of the test is as follows:—A charge of the explosive under test is stemmed in a small cannon in a suitable manner. The cannon is placed so that it can be discharged into a firing gallery, about 2 feet 6 inches in diameter and 28 feet long. A mixture of gas and air at its most explosive point is sent through the gallery. While this is passing the cannon is fired, and the whole force of the explosive expended in blowing out the stemming. This creates an exceedingly high temperature. If this high temperature is persistent enough to ignite the gas mixture in the gallery once out of twenty such shots the explosive is considered not to be sufficiently safe to be placed upon the "permitted" list.

Thus a "permitted explosive" is simply an explosive proved under certain conditions to be safer than others, and, in the opinion of the Home Office experts, sufficiently safe to be placed upon the Schedule of the Explosives Order. A "permitted explosive" is not absolutely safe; *nor is it flameless.* There is no such thing as a completely safe explosive, which may be used with freedom in any circumstances. *All explosives will ignite gas or dust* if the conditions are favourable.

The action of permitted explosives is much quicker than that of blasting powder, and usually the active chemical change is completed before the walls of the shot-hole yield. Should this not be the case, there is a danger that active and exploding material will come in contact with the outside atmosphere. As a rule no solid matters result from the use of permitted explosives, and the residual gases are of a comparatively low temperature.

Nitro-Glycerine Explosives.—A large number of explosives on the "permitted list" depend upon this substance for their strength. Pure nitro-glycerine is a pale yellow oily *liquid*, prepared by dissolving glycerine in strong nitric and sulphuric acids.

If ignited in the open air the oil burns rapidly without explosion; if subjected to a blow of medium strength or to the action of a detonator it explodes violently. If perfectly exploded the resultant gases are harmless. It is possible, however, that the chemical changes may not be theoretically perfect, in which case *highly poisonous nitrous fumes* may be given off, and also a considerable quantity of *carbon monoxide.*

Nitro-glycerine freezes at 40° Fah. In this condition it is more dangerous to handle, its sensitiveness to shock or concussion being considerably increased, whereas it is not so responsive to a detonator. Thus there is a greater possibility of "miss-fires" and "hang-fires" in the winter time with explosives depending on nitro-glycerine for their force than there is in summer. Frozen nitro-glycerine explosives should be thawed in proper warming

pans and never subjected to direct heat, on account of the risk of premature explosion.

Nitro-glycerine is not used in its oily state, but is absorbed by gelatinous or earthy matter to form a plastic mass which can be made into cartridges.

Dynamite consists of a mixture of nitro-glycerine and an absorbent earth in the proportions of three to one. The earthy substance is used purely as an absorbent, and takes no active part in the development of force. This explosive has great shattering power, and is eminently suitable for heavy stone-work, but unfortunately it will not pass the Home Office test, hence its use is not permitted in safety-lamp or dusty mines.

The Carbonites.—This is a generic name applied to a group of explosives having their main features in common. They are much slower in action than dynamite, and have about one-third the strength.

The explosive constituent is nitro-glycerine absorbed in a mixture of wood meal and potassium nitrate, in the proportion of one part nitro-glycerine to about three parts of the absorbing mixture.

Owing to the slow speed of detonation explosives of this class are eminently suitable for coal getting and ripping in soft shales. They are considered to be among the safest of explosives for use in gassy mines, but, as a rule, they are more liable than others to give off large volumes of *carbon monoxide.*

It is particularly important, therefore, when driving headings or other narrow workings with the assistance of any member of the carbonite group of explosives, that the ventilation should be kept in good order, so that the fumes from shot-firing may be rapidly cleared away.

Any explosive mentioned in the First Schedule of the Explosives Order containing less than 30 per cent. of nitro-glycerine, and not containing ammonium nitrate may be considered to belong to the carbonite group, and to have the general characteristics described above. It should be remembered that as a rule the names applied to explosives are commercial names, and have no chemical significance.

The Gelatines.—In all members of this group the nitro-glycerine is gelatinised by nitro-cotton. Nitro-cotton is in itself explosive, and is made by treating clean cotton waste with a mixture of nitric and sulphuric acids. At ordinary temperatures it is a plastic solid. In the manufacture of *blasting gelatine*—one of the strongest explosives in existence—about 7 per cent. of nitro-cotton is liquefied by heating, and slowly added to and mixed with 93 per cent. of nitro-glycerine. On cooling, this mixture sets into a stiff jelly-like substance, which is comparatively safe for transport. Blasting gelatine is much too strong for ordinary mining purposes.

By mixing 80 per cent. of blasting gelatine with 20 per cent. of a nitrate mixture, a substance known as Gelatine Dynamite is formed. By reducing the percentage of blasting gelatine to about 65, and making up with a mixture of wood-meal and potassium nitrate, the explosive known as *Gelignite* is obtained.

None of the gelatines mentioned above will pass the Home Office test.

Owing to the plastic nature of this class of explosive and the fact that all members of it can be used under water or in damp conditions with perfect security, attempts were made to tame down its activity in order to pass the official test.

This was finally effected by adding about 10 per cent. of oxalate of ammonium to the gelignite mixture. The ammonium salt contains a large percentage of water of crystallisation, hence the evaporation of this absorbs a good deal of heat from the gases of explosion, and cools the flame.

In this form the explosive passes the test, and is supplied by various firms, under such names as Samsonite, Stowite, Arkite, Rippite, &c.

These explosives are the strongest on the permitted list, and are often used in tunnel driving and shaft sinking. Like all other members of the great nitro-glycerine class of explosive, they are easily frozen, and equally dangerous to handle in this condition, and if improperly detonated are apt to give off *carbon monoxide and nitrous fumes.*

Reference may be made at this point to the accident at Thorne Colliery, in Yorkshire, in 1910. In the course of sinking this colliery a round of 15 shots, each charged with 1¼lb. of gelignite, was fired. Immediately after firing the men returned to the shaft bottom. A number of the men became very ill within a few minutes, and had to cling to the shaft side for support. On returning home several became seriously ill, and one died next day.

In his report H.M. Chief Inspector of Mines states: "The symptoms showed that the men affected were suffering from the effects of carbon monoxide and nitrous oxide poisoning."

This accident suggests the necessity of effectively ventilating sinking pits, and the prevention of an immediate return to the bottom of the pit after firing a heavy charge of a nitro-glycerine explosive.

A second accident of interest occurred at Hazelrigg Colliery in January, 1912, which involved one death.

Two men had prepared and fired simultaneously four shots charged with Samsonite. After waiting for twenty minutes they returned to the face to stem another shot. Before this could be effected the men were overcome. It was stated at the inquest that the brattice was 10 yards back. A verdict was returned "that deceased died from carbon monoxide gas inhaled by him after firing shots charged with Samsonite."

Other accidents might be quoted, but probably these two will be sufficient to emphasise the reality of the danger arising from the use of nitro-glycerine explosives in places which are ineffectively ventilated. As a rule the production of carbon monoxide is greatest in holes that have been undercharged.

Nitrous fumes may be expected if inferior or defective nitro-glycerine explosives are used, and where, due to some defect, the explosive *burns* instead of explodes, or has failed to detonate. When nitro-glycerine explosives are burned in ordinary air large quantities of nitrous fumes are formed.

In *all* cases of heavy shot-firing in which large quantities of nitro-glycerine explosives are used, both gases should be expected, and precautions taken to guard against their physiological effects.

The symptoms of carbon monoxide poisoning have been referred to in these articles several times, and further reference need not be made.

Nitrous fumes may be detected by a characteristic smell—that of strong nitric acid. Students in attendance at an Institute or School having a chemical laboratory should acquaint themselves with these fumes.

If present in any quantity an irritation of the air passages and of the eyes is felt, which, however small, should be accepted as a sign of danger. Though such an exposure may cause little inconvenience at the time, after effects in the form of acute bronchitis and inflammation of the lungs may arise, which may be fatal within two or three days.

Ammonium Nitrate Explosives.—Explosives which have this substance as their base are quite distinct from those based on nitro-glycerine. Ammonium nitrate is not so sensitive to shock as nitro-glycerine, nor has it such explosive violence. By mixing the ammonium nitrate with a combustible substance it is found that the explosive violence is increased; hence explosives of this type usually consist of 80 to 90 per cent. of ammonium nitrate with 10 to 20 per cent. of other substances.

Originally, explosives of this class were claimed to be flameless, but experience has proved that there is no such thing as a flameless explosive. It is admitted, however, that many explosives of this type are suitable for coal mines owing to the relatively low temperature of the resultant gases.

If properly detonated the resultant gases are harmless, consisting chiefly of steam and nitrogen. No solid matters are produced. If improperly detonated poisonous products may be expected, though not to the same extent as from nitro-glycerine explosives.

In strength, explosives of this class are intermediate to the carbonites and the gelatines, being more shattering in effect than the former, but less so than the latter.

Ammonium nitrate explosives are more difficult to detonate than nitro-glycerine explosives. As a rule a No. 8 detonator must be used, which is twice as strong as the No. 6 usually used for nitro-glycerine. This is an important point, as the use of a No. 6 detonator may result in a "miss-fire."

It is also important to prevent these explosives from coming in contact with moisture. Ammonium nitrate absorbs moisture very rapidly, and by doing so loses its explosive properties. It is for this reason that all explosives of this class have to be enclosed in waterproof cartridge cases. Should this waterproof case be punctured the explosive rapidly loses its power.

Owing to the difficulty of detonating ammonium nitrate attempts have been made to obtain increased sensitiveness by adding some nitro-glycerine. Monobel Powder is one of the best examples of this mixed class, and contains about 80 per cent. of ammonium nitrate and 10 per cent. of nitro-glycerine. This has to be kept water-tight to preserve the explosive power of the cartridge. As this contains nitro-glycerine, carbon monoxide may be expected in some degree on imperfect detonation. It can be exploded with a No. 6 detonator.

All members of the nitro-glycerine, the ammonium nitrate, and the mixed groups of explosives are *detonants*, and must be subjected to the shock of an exploding detonator of a suitable strength to explode them.

In order to avoid the risks due to handling detonators, a class of explosive which can be used without a detonator is popular in some districts. *Bobbinite* is possibly the best representative. This is similar in its action to blasting powder, and the resultant gases are similar. It is usually fired by an electric fuse containing five grains of gunpowder. A detonator *must not* be used.

Replies by M.E. to Correspondents.

A. W. (*Ruabon*).—In reply to your query, it would appear that holders of a first or second-class certificate occupying the position of deputy must obtain a certificate in accordance with Section 15 (1) (*b*). The exemptions under Sections 15 and 123 (*b*) (*ii*) will of course apply.

You will notice that an *alternative* is offered in Section 15 (1) (*a*). *Either* he must have a first or second class certificate *or* he must be 25 years of age, &c.

This in effect means that a person at 23 years of age may become a deputy if he possesses a first or second class certificate. See Section 9 (2) (*b*). If he does not possess such a certificate he cannot be a deputy until he is 25 years of age.

The requirements of 15 (1) (*b*) are *additional* to the alternatives of 15 (1) (*a*). This in effect means that a person cannot be a deputy unless he has a first or second-class certificate *and* has obtained the certificate in the prescribed form, &c., *or* unless he is 25 years or upwards, &c., *and* has obtained a certificate in the prescribed form, &c.

Section 15 (1) (*c*) is also additional to 15 (1) (*a*).

G. W. (*Rotherham*), *S. W. G. M., and G. Kershaw* (*Sheffield*).—Thanks for your letters. The answer to *Constant Reader* in last issue of the Journal was unfortunately worded. Your reading of the clause is perfectly correct. All First or Second Class men must obtain the prescribed certificate required by Section 15 (1) (*b*) if they wish to hold a deputy's position. This applies to First or Second Class certificates granted under the new Act or under the 1887 Act.

F. E. (*Pemberton*).—As you hold a second class certificate you are eligible for appointment as an under-manager. Section 5 (1) prohibits a person being a manager if he is less than 25 years of age, notwithstanding that he may have a first class certificate. Under Section 9 (2) (*b*) a person may apply for a First or Second Class certificate as soon as he is 23 years of age. In the case of an under-manager the granting of this certificate legalises an appointment.

COLLIERY DEVELOPMENTS AT EDLINGTON.

Recent developments at the Yorkshire Main Colliery at Edlington are said to have been very satisfactory. The management have had great difficulties to contend with in unexpected faults in getting through the shaft pillar, but these troubles have now been entirely overcome. The coal is of excellent quality. On the west side the difficulties were much greater than on the east, on account of the very faulty ground. The cages have been fixed, and the screens and other plant, capable of dealing with 5,000 to 6,000 tons per day, are now in working order. The houses already built at New Edlington are rapidly filling, and it is clear that to keep pace with the developments of the colliery some hundreds of houses will be required. Quite a town is springing up, and already there is a population of about 600.

EXAMINATION [AND OTHER] QUESTIONS ANSWERED.

By TYKE.

Equivalent Orifice.

Nova Scotia Student *asks "How the constant ·00038 is arrived at in the formula relating to the 'equivalent orifice,' as applied to mine ventilation."*

A.—The equivalent orifice means an orifice or opening in a thin plate which offers a resistance to the air passing through it. By the term "equivalent" we mean that the resistance encountered by the air in passing through the orifice is equivalent or equal to the resistance that is encountered by all the air in passing through the mine. The resistance to the air passing through the mine is usually expressed as ksv^2, where k = coefficient of friction, or resistance per square foot of rubbing surface for a velocity of 1,000 feet per minute; s = rubbing surface in square feet; and v = velocity in thousands of feet per minute. Then the "equivalent orifice" may be looked upon as an artificial obstruction to the air-current that will give the same amount of resistance.

Now the quantity q of air passing per minute in a mine is equal to VA, where V = velocity of air in feet per minute; and A = area of roadway in square feet, hence

Quantity in cubic feet per minute = VA.

But there is a theoretical volume of air which may be considered from the laws of falling bodies by the following train of reasoning:—

In the ventilation of a mine it is obvious that the air starts from rest, that is, from an atmosphere at rest above the surface, and that it attains a final velocity in the mine. If we consider a body falling freely from some great height, and that the motion of the body is due to gravity alone, it can be shown that in the first second of the time occupied in falling, the body falls through a space of $\frac{1}{2}g$ feet, or $\frac{g}{2}$ feet; and again, that at the end of the first second of time the body will be falling at the rate or velocity of g feet per second. The body is moving with uniform acceleration of g feet per second per second, hence

The velocity of the body at start is 0 feet per second.

Its velocity at end of first second is g feet per second.

Its velocity at end of second second is $2g$ feet per second.

Its velocity at end of t seconds is tg feet per second.

Starting from rest the velocity at beginning of first second = 0, therefore the space passed through during the first second must be a mean space due to the differing velocity. It is feasible to take velocity at start as 0, and velocity at end of first second as g feet = 32 feet, therefore space passed through during the first second = $\frac{0 + 32}{2}$ = 16 feet. The space passed through during the second second will be the mean of the initial and final velocities of that second. Taking g = 32, the velocity of the body at beginning of second second (*i.e.*, end of first second) is gt = 32 feet per second; and the velocity at end of second second is $gt = 32 \times 2 = 64$ feet per second. Then mean space passed through = $\frac{32 + 64}{2}$ = 48 feet.

To find total space passed through from start of motion up to end of any given second.

To end of first second = 16 feet = $16 \times 1^2 = \frac{1}{2}g \times 1^2$.

To end of second second = $16 + 48 = 16 \times 4 = \frac{1}{2}g \times 2^2$.

To end of third second = $16 + 48 + 80 = 16 \times 9 = \frac{1}{2}g \times 3^2$.

To end of t second = $16 \times t^2 = \frac{1}{2}g \times t^2$.

Hence a body falling freely from a height will fall with a uniform acceleration g feet per second per second. The acquired velocity v and the distance fallen s at the end of t seconds will be given feet and feet per second respectively by the formulæ $v = gt$ .. (1). $s = \frac{1}{2}gt^2$ .. (2).

Or $v = 32t$; $s = 16t^2$,

taking gravity = 32, which is more used in practice than the more accurate value, g = 32·2 feet.

Now if we square equation (1) we get $v^2 = g^2t^2$, and if we multiply equation (2) by $2g$, we get $2gs = g^2t^2$, but since $g^2t^2 = v^2$, then $v^2 = 2gs$.

Substituting h for s, we get the more usual formula used in mining as $v^2 = 2gh$, from which $v = \sqrt{2gh}$.

If h be measured in feet, and g taken as $= 32$, then this becomes $v = 8\sqrt{h}$ feet per second.

Applying this formula to mine ventilation, it is necessary to know the true value of h. It will be seen that the theoretical height refers to the *motive column*, which is a column of air in or above the downcast having the same density as the air in the downcast, and having a total weight equal to the difference of weights of the downcast and upcast columns of air, therefore height of motive column in feet $\times$ density of air in downcast *equals* p, the ventilating pressure. Since the ventilating pressure = W.G. in inches $\times$ 5·2, then motive column

$$h = \frac{P}{\delta}.$$

$$\text{Or } h = \frac{\text{W.G. in inches} \times 5{\cdot}2}{\delta}.$$

Where δ = density of air in downcast column.

The density of air, or weight in lb. per cubic foot, may be found by the formula:—

$$W = \frac{1{\cdot}32079 \times B}{(459 + T)}.$$

Where W = Weight of a cubic foot of air;
B = height of barometer in inches;
T = temperature in degrees Fahrenheit.

The density of air at usual atmospheric pressure and temperature may be taken as ·076lb. We are now in a position to collect these formulæ together and apply them as one. It has been seen that $q = av$ under ordinary conditions. Under frictionless conditions, in a theoretical sense, assuming the air to act under gravity,

$q = a \times \sqrt{2gh} = a \times 8 \times \sqrt{h}$ cubic feet per second.

But the quantity of air flowing through the orifice would not equal av, because of the *vena contracta*, or contraction of the current, in passing through the orifice. Demonstrations have shown the coefficient of the *vena contracta* for such an orifice (an orifice in a thin plate), as Murgue suggested, to be 0·65. The quantity of air passing through the orifice then

$$q = 65a \times 8\sqrt{h}, \text{ and } a = \frac{q}{{\cdot}65 \times 8\sqrt{h}}.$$

Where a = area of equivalent orifice in square feet.

For one inch of water gauge the height of motive column, h, would be $\frac{5{\cdot}2}{\delta} = \frac{5{\cdot}2}{{\cdot}076}$ feet, therefore 1 inch of water-gauge would represent a height of 68·42 feet. Then we have—

Where q = quantity of air passing in cubic feet per minute;
W.G. = water-gauge in inches;
a = area of equivalent orifice in square feet;
60 = seconds in a minute.

$$a = \frac{q}{60 \times {\cdot}65 \times 8\sqrt{68{\cdot}42\ \text{W.G.}}} = \frac{q}{312 \times 8{\cdot}27\sqrt{\text{W.G.}}} = \frac{q}{2580\sqrt{\text{W.G.}}}.$$

Dividing 2580 into 1, we get $a = \frac{{\cdot}00038\ q}{\sqrt{\text{W.G.}}}$.

It should be remembered that the above area is found for conditions when the quantity of air is stated in cubic feet per minute; where q is taken in thousands of cubic feet per minute the formula becomes $a = \frac{{\cdot}38\ q}{\sqrt{\text{W.G.}}}$.

Arithmetic.

Q.—*How many tons of coal of specific gravity 1·3, and 3 feet 3 inches thick, are there in an area of 1,000 acres? 1,000,000 tons of coal have been brought to the surface. How many acres are left?—Submitted by* Welsh Student.

A.—Coal of specific gravity 1·3 weighs 1·3 × 62·5 = 81·25lb. per cubic foot.

The quantity of coal *per acre* = 4840 × 9 × 3¼ cubic feet.

$$\text{Tons per acre} = \frac{4840 \times 9 \times 3{\cdot}25 \times 81{\cdot}25}{2240} = 5{,}135 \text{ tons.}$$

Then produce of 1,000 acres = 5,135,000 tons.

If 1,000,000 tons have been brought to the surface, then approximately 4,000,000 tons remain, or about four-fifths of the area, then 1,000 acres × $\frac{4}{5}$ = 800 acres left (approximately).

The above calculation shows no allowance for waste, faults, or bad coal, and it is usual to make an allowance of about 20 per cent.

When the specific gravity is known, as in this case, it is sometimes better to find the product of the seam in tons per inch of thickness per acre. The calculation then becomes

$$\frac{\text{Area in square feet} \times \text{S.G.} \times 62{\cdot}5}{12 \times 2240} = \text{tons per inch of seam.}$$

$$\therefore \frac{4840 \times 9 \times 1{\cdot}3 \times 62{\cdot}5}{12 \times 2240} = 131{\cdot}6 \text{ tons per inch per acre.}$$

The thickness of seam is 3 feet 3 inches, *i.e.*, 39 inches, then tons per acre of seam will be equal to 131·6 × 39 = 5,132·4 tons, not allowing wastage.

If we allow 20 per cent. for wastage, then the produce of such a seam will be 131·6 — 26 = say 105 tons per inch of thickness per acre, or for the seam 105 × 39 = say 4,100 tons per acre.

Surveying.

Q.—*On a plan drawn to a scale of 2 chains to the inch two pits are 9¾ inches apart. What would they be on a scale of 6 inches to the mile?—Submitted by* Welsh Student.

A.—First find the actual distance between the two shafts. If they are 9¾ inches apart on the plan, and the plan is drawn to the scale of 2 chains to the inch, then for every inch on the plan a distance of 2 chains or 2 × 66 = 132 feet is represented. The distance between the two pits then = 132 × 9·75 = 1,287 feet.

Now on a scale of 6 inches to the mile, what distance on the plan would represent 1,287 feet? One mile, or 5,280 feet, is shown by 6 inches on the plan, then

As 5280 : 1287 : : 6 inches : x.
∴ 480 : 117 : : 6 : x, and

$$x = \frac{117 \times 6}{480} = 1{\cdot}4625 \text{ inches, therefore on the second plan}$$

the distance apart of the two pits is 1·4625 inches.

Or, a scale of 2 chains to the inch = 1,584 inches per inch, or $\frac{1}{1584}$ actual size.

A scale of 1 mile to 6 inches = 63,360 inches per 6 inches, or $\frac{1}{10560}$ actual size.

As the ratio of the actual sizes so is the ratio of any length on one plan to a corresponding length on the other plan; a distance of 9¾ inches on the larger scale corresponds to x on the smaller scale, or as

10560 : 1584 : : 9·75 inches : x.
20 : 3 : : 9·75 : 1·4625 inches.

LOST IN A COAL MINE.

A report states that Albert Munday, a fireman employed at the Ebbw Vale Co.'s Waunllwyn Colliery, recently had a very trying experience. As is his usual custom, Mr. Munday set off to examine the district of which he is fireman, but during his tour of supervision he lost his way in a portion of the colliery but little frequented and used. He was missed, and a search party, under the guidance of Mr. Evan Parry, the manager, was organised, but it was not for some considerable time after the day shift had come up the pit that Mr. Munday was found, happily none the worse for his five or six hours' solitude. He had got into the old workings, and fearful lest he might make a false step, decided to remain where he was until guides arrived to help him to safety.

PREVENTION OF OVERWINDS.

By UT PROSIM.

The Coal Mines Act (1911), Section 40, decrees:—"Where the apparatus ordinarily used for raising or lowering persons to or from the surface is worked by mechanical power it shall, if the shaft is vertical, be provided with a detaching hook, and, if the shaft is more than one hundred yards in depth, shall also be provided with an effective automatic contrivance to prevent overwinding. The provisions of this sub-section shall not apply to any mine or class of mine which is exempted by the Secretary of State on the ground of special circumstances of the mine or class of mine, and shall come into operation on the first day of July, nineteen hundred and thirteen, or such later date as, in view of the circumstances of the mine, may be fixed by the inspector of the division."

The new Act plainly states that an effective automatic contrivance to prevent overwinding is a separate apparatus in addition to the ordinary detaching hook.

Hitherto the provision of a detaching hook has generally been considered a practical compliance with the spirit of the Coal Mines Act, 1887 (Section 49, Rule 26). Strictly speaking, a detaching hook is not a contrivance to prevent overwinding, as it only comes into action after an overwind has taken place. The detaching hook only provides a safeguard against the effect of an overwind on the ascending cage—the down cage has no protection, and thus suffers the full effect of an overwind.

To comply with the new Act, should the engineman at any time lose control, the automatic contrivance must then come into action, and take over the control of the engines and *prevent* an overwind.

The following reports on accidents due to overwinding prove the great need there is for an efficient overwind preventer.

"By shaft accidents, 25 persons were fatally injured by 18 accidents, as against 11 accidents and deaths in 1909. Nine were killed by two accidents due to overwinding, and at the fatal accident inquiries in connection with both of them they were found to be due to lapses or mistakes on the part of the winding engineman. At neither of the collieries were detaching hooks or controllers attached to the winding engine to prevent overspeed and overwinding provided."—*H.M.I.M. Report, Scotland District, 1910.*

"Only three non-fatal accidents require special notice. All were caused by mistakes by the winding engineman, the descending cage being dashed violently into the bottom of the shaft in each instance. It is desirable that every large winding engine should be fitted with an apparatus to shut off steam and apply the brake automatically if the engine exceeds a certain speed at certain points."—*H.M.I.M. Report, Yorkshire and North Midland District, 1910.*

"Two accidents by overwinding caused three deaths and injuries to 19 persons. The use of controllers on large winding engines for the prevention of overwinding, is slowly increasing."—*H.M.I.M. Report, South Wales, 1910.*

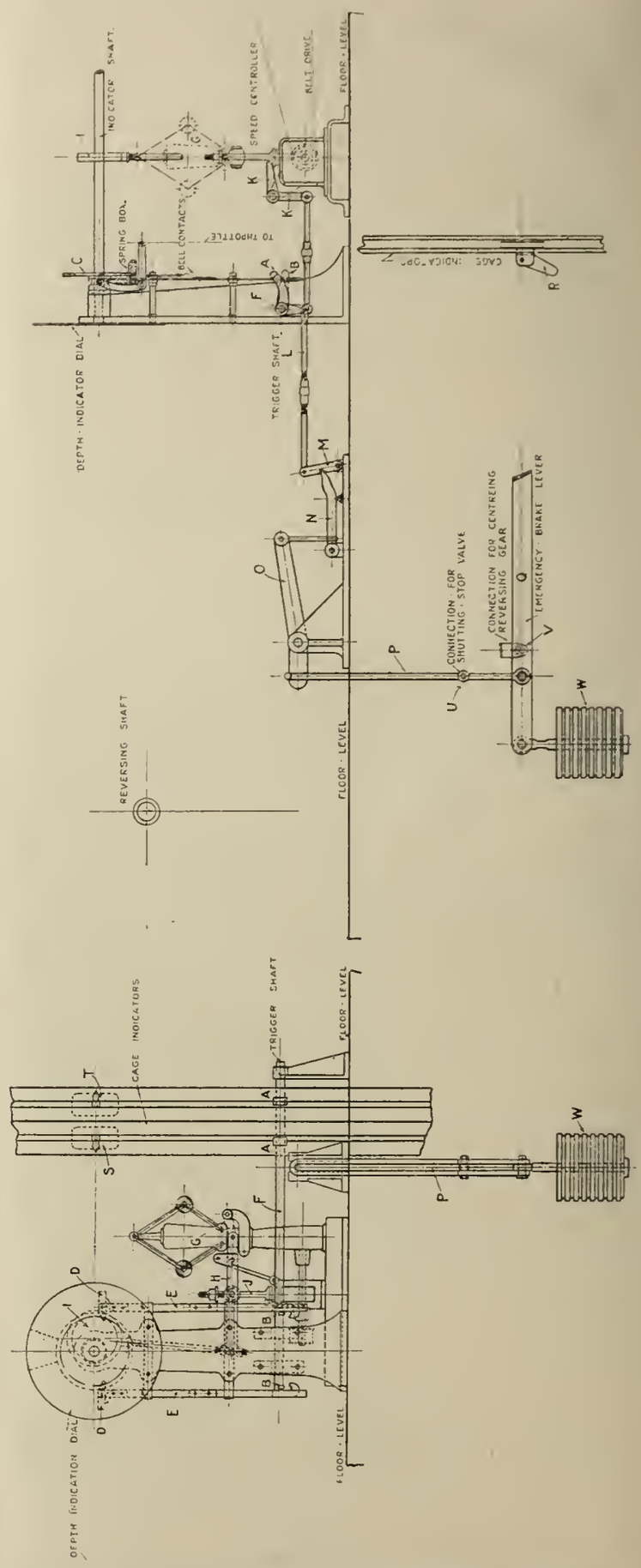
An efficient overwind preventer, known as the Caledonia Controller (Walker's Patent) has only recently been placed on the market. A paper read before the Mining Institute of Scotland by Mr. John Paul gives a full description of this gear, as fitted to the winding engines at the Mary Pit of the Lochgelly Iron and Coal Co., Ltd.

In designing this overwinding preventer the object was to provide a gear efficient in action, simple in detail, and at a moderate cost. The following is a brief description of the Caledonia Controller, made by Andrew Barclay, Sons and Co., Ltd., Caledonia Works, Kilmarnock:—

Suitable for engines with steam brakes or without steam brakes.

The disc *C* (right-hand view) is mounted on the winding indicator shaft, and slides on a feather. It is coupled to the handle of the main steam throttle valve in such a way that when the steam is shut off the disc is moved to the right along the indicator shaft.

Catches *DD* (shown on the left-hand view) are so placed that a pin, projecting from the spring box in the disc *C*, will engage one of them (depending on the direction in which the indicator shaft is revolving), unless the disc *C*, and the pin with it, are moved out of the way, and this can only be done by closing the main steam throttle. If the pin on the disc *C* engages with either of the catches *D*, one of the rods *E* is raised, and a bell rings, warning the engineman to shut off steam. If steam is then shut off, the winding may be completed under



Firemen and the Mines Act.

Being the articles of M.E. in Pamphlet Form (16 pages) on the Coal Mines Act, 1911, as it Affects the Appointment, Qualifications and Duties of Firemen, Examiners or Deputies.

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the control of the engineman. If steam is not shut off, the continued lifting of the rod *E* will act by a hook on its lower end, on a lever *B* (shown in both views) which will release the trigger at *M* (on right-hand view), thus allowing the weighted emergency brake lever *Q* to apply the brake, and through suitable mechanism will place the reversing handle in the centre, and automatically shut off steam, so that the engine will be brought to rest before the cage reaches the pit-head.

Excessive speed is prevented by the combined action of a governor *G* and an eccentric *I* (seen in both views). These are connected to a lever *H* (left-hand view) in such a way that when the speed is too high the rod *J* (left-hand view) is raised, and through the levers *K* (right-hand view) the trigger *M* is released, and the action already described takes place.

Provision is made for stopping the cage at the pit-head by means of the pawl *R* (right-hand view), the position of which is controlled by the cage, and is such that at the end of the wind the pawl *R* is ready for acting on the lever *A* (right-hand view). If the cage travels too far the trigger *M* is released by the pressure of the pawl on the lever *A*. The same thing happens if the engine is started in the wrong direction at the commencement of a wind. In these last two cases the engine is stopped very quickly.

Fig. 123

An attachment is fitted to rod *J* which is quickly put in and out of gear by a small handle convenient to the engineman to allow for a slow speed when winding men, and a quick speed when winding coal.

The action of the controller does not interfere with the freedom of the engineman to follow up the automatic braking by his hand or foot brake, or steam brake, as the case may be, or to reverse his engine, or to open his throttle. *After acting, the gear is rapidly reset.*

A recorder can be applied if desired to keep a record of the number of times the controller is in action.

The Caledonia Controller is fitted to winding engines with the guarantee that it shall perform the following operations in an efficient manner:—

(*a*) To stop the engines before the cage reaches the surface in the event of the engineman failing to shut off the steam, and apply the brakes at the usual time to bring the engines to rest at the surface.

(*b*) To stop the engines, if, after the engineman has shut off the steam and applied the brakes, the speed should be so high as to make an overwind imminent.

(*c*) To stop the engines if the cage is likely to overwind at a slow speed.

(*d*) To stop the engines in the event of their being started in the wrong direction.

SURVEYING.

By COLLIERY SURVEYOR.

Figure 123 shows two kinds of North lines, of simple design and neat. *Figure 124* represents various borders or edging for a plan, either of which is neat without being unduly elaborate. The draftsman should beware of concentrating too much artistic skill upon a bordering, otherwise appreciation of a well executed

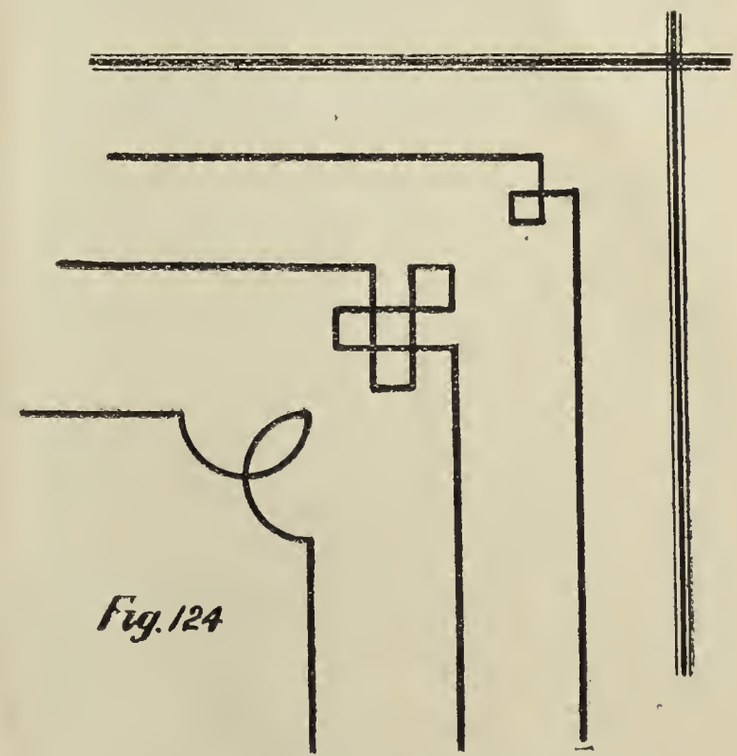

Fig. 124

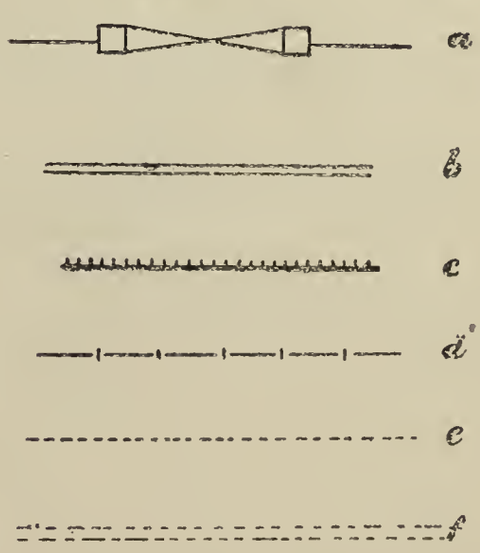

Fig. 125

plan will be lost in admiration of the border. A neat bordering and North point add greatly to the appearance of a plan, and the student should practice often in this direction. To give a good border uniformity in thickness of line is essential. *Figure 125* depicts certain conventional signs used for surface plans: (*a*) Represents a gate, (*b*) a wall, (*c*) a close paling, (*d*) a post and rail fence, (*e*) a footpath, (*f*) a bridle path or cart track. This figure has been taken from USILL'S *Surveying*.

NOTES FROM WALES.

By BRYCHAN.

Haulage: The Transmission of Power.

The motive power agents employed for haulage may be (*a*) steam, (*b*) compressed air, (*c*) electricity, (*d*) ropes. The latter may, however, be considered as actuated by either of the first three.

Steam.—This is a very convenient agent for power transmission, entailing as it does only two transformations of energy, viz., heat to steam, and steam into mechanical work. Produced in a boiler, it is conveyed to the motor through pipes, and the distance between the generating point and the point where it is used may vary from a few feet to a mile.

Under favourable conditions it is extremely economical, *i.e.*, in the case of winding, haulage or ventilating engines situated close to the boilers and requiring the minimum length of piping. In such a case there will be practically no drop in pressure between the boiler and the engine. Again for transmitting to underground engines, when the steam column passes down through the upcast shaft, it has the effect of causing a current of air to circulate owing to its heating effect upon the air column in the shaft. An extremely convenient agent, and the efficiency given will depend upon the amount of care taken in carrying out certain essential points, *i.e.*, points essential to high efficiency. The chief source of loss is through condensation, and this condensation increases as the length of piping and extent of radiating surface. It may to a great extent be counteracted by covering the pipes, flanges and all, with some good non-conducting composition, such as slag wool. Great attention must be paid to the efficiency of the joints, and also to the strength and design of the piping. Leaky joints are a source of annoyance, while a blown-out joint is a source of danger, and a burst pipe still more so. To reduce the risks of broken joints and burst pipes, expansion pipes must be introduced into lengths of steam piping, and the whole length should be carried either upon rollers or suspended at points between the expansion joints. If steam is conducted underground for considerable distances from the shaft bottom the pipes should be carried through the return in all cases. By this means the intake air is not heated, and any accident causing an escape of steam will not cause any worry in-bye, (It is here assumed that the motor is made to exhaust into the return). Exhaust steam has, however, in most cases a pernicious effect upon the roof and sides.

Any depressions occurring in a line of piping should always be provided with drain cocks to drain the water of condensation, as the presence of water in a steam pipe line is a serious danger. The size of pipes should be such that the velocity of the steam should not exceed 6,000 feet per minute.

Compressed Air.—This is a very convenient and approved method of transmitting power into mines. Provided certain precautions are carried out it is absolutely safe for use in any class of mine, and the exhaust, if anything, aids the ventilation. The great drawback to its use is that an additional transformation of energy is required, *i.e.*, the steam is utilised to compress the air, and the costly machinery required for the purpose. Besides this additional first cost and subsequent upkeep, there is a decided loss in compression owing to the fact that air expands in accordance with the law of Charles or Gay Lussac :—*When any gas is heated the volume increases.* When air undergoes compression it acquires an increase of temperature, and its volume therefore is increased. If we had only Boyle's law to contend with, where PV = a constant, we should get exactly the same amount of work from the motor as was put into the generator, less a certain allowance for frictional resistances in both engines and in the conduit.

But this increase of volume due to temperature is a decided loss unless the air is again heated before using in the motor, or the air is used in the motor before it loses the heat of compression. In mines both are practically out of the question, and therefore the air on its way from generator to motor loses this heat, and the pressure drops owing to the expansion that takes place.

Just as compression produces heat, so expansion produces cold, and the air at the motor in expanding absorbs heat from the surrounding air, and such a degree of cold is produced as frequently to form ice on the exhaust ports. Exhaust pipes with air motors are not necessary and should not be used.

The air compressing engine usually consists of a pair of coupled engines, horizontal, direct-acting, with air and steam cylinders in the same straight line, and a heavy flywheel placed on the crank shaft; with cranks at right angles. This has been found the best arrangement, when considering the fact that at the beginning of the stroke the maximum steam pressure has practically nothing to do. The air cylinders are provided each with two inlet and two outlet valves. There are different varieties of these valves. Some are controlled by springs, while others, such as the Riedler type, are operated mechanically at a certain point in the stroke from outside. It is necessary to adopt some means of reducing the heat generated during compression. Unless this is done a point would soon be reached when working would be impossible; or even assuming it possible to go on working the efficiency would be practically nil.

There are two chief varieties: (1) Dry compressors, (2) wet compressors. In the first the cylinders are surrounded on the outside by a water tank through which a stream of cold water is kept running constantly. The water has a cooling effect upon the cylinder walls, and consequently upon the air inside. This effect is, however, but slight as the cylinder walls are not good conductors of heat. In No. 2 method either a fine spray of cold water is introduced into the cylinder at the moment of compression, thereby coming into more or less intimate contact with the air, or a column of water is interposed on both sides of the piston, and between it and the air which is to be compressed. This latter system has two drawbacks. Water is proverbially a bad conductor of heat, and it is said that the thin film of water next to the compressed air becomes heated by it, and, failing to transmit it to the fluid mass sufficiently quick, soon becomes too hot to be of much use. Besides, the momentum of a moving column of water reversed in direction at every stroke is objectionable, except in the case of slow moving engines.

In the best practice the air is compressed in two stages, being cooled in what is termed an inter-cooler after the first compression. This certainly reduces the risk of inflammation of carbonaceous deposits present in the cylinder or in the receivers and pipe line, as the heat generated in each cylinder is less than if the air is compressed to its final pressure in the same cylinder, and at one operation.

Compressed air is reputed as absolutely safe under all conditions, but, unless certain precautions are observed, there are grave risks attached to its use. Unless the very best lubricant with a high flash point is used, and which will not deposit carbon at high temperatures, there is always a danger of inflammation amounting to explosion in the compressor or for some distance along the pipe line—as instance the accidents at Rylope, Co. Durham, in 1883; at Newbattle, Scotland, in 1888; at Clifton Colliery, Nottinghamshire, 1897; Carn Brea Tin Mine, Cornwall, in 1885; and Aberbeeg Colliery, 1902.

In addition to the above precaution, the following are important:—

(1). Temperature of compressed air should be constantly observed and recorded.

(2). Reducing the temperature of the compressed air to the lowest possible point.

(3). The frequent removal of the deposits from the cylinder valves, receivers, and all accessible pipes, which if allowed to accumulate might considerably restrict the area of outlet for the air, and through this cause an abnormal rise in temperature.

(4). The air supply should be drawn from a point where there is no contamination by dust, and from outside the engineroom.

The losses incidental to compressed air are as follows:—

(1). Friction of the compressor.

(2). Loss by not drawing the air from outside enginehouse.

(3). Losses in cylinder during compression owing to heating.

(4). Clearance losses.

(5). Insufficient inlet and insufficient outlet, *i.e.*, difficult discharge.

(6). Defective cooling arrangements.

(7). Poor lubrication.

(8). Losses in the pipe line.

The air that fills the air cylinder at the commencement of the stroke has come from three sources: (1) that which was left in the clearance spaces of the cylinder since the previous stroke; (2) that which has leaked from the discharge valves and past the piston; (3) the air drawn from the atmosphere.

Inasmuch as it is difficult to always ensure tight valves and pistons, it is evident that a high speed compressor offers on this account the advantage of lower temperature of the air during compression. Examples of this type are Reavell and "Sentinel" Compressors. Good modern economical compressors are of the double stage type driven by compound or multiple expansion steam engines. The clearance spaces of the air cylinders are kept as small as possible; both low and high pressure air cylinders are water-jacketed and an intermediate air cooler is employed. The air pipes and valves are of large diameter, thereby reducing the friction.

PRIZE COMPETITION AWARDS FOR VOL. XXII.

During the volume ending with the present issue we have had evidence that the system of awarding marks in the Prize Competition has been appreciated, and this form of examination will be continued during the next twelve months. In making this announcement it will be understood that suggestions from readers and competitors will be appreciated.

It is hoped to maintain the usefulness and educational value of the Prize Competition, and all who propose to take an active part therein should make a beginning now, as it is the aggregate of marks that counts in the award of the Prizes. Enter the lists with the present issue. There is no reason why you should delay, and *we do not charge any entrance fee.* Each question is given a total value of 15 marks, and we show how many marks each Competitor has obtained, a system of examination affording an opportunity of gauging the value of the work done. Read the conditions, and be careful at all times to observe the rules of the Competition. Success with one question does not place another out of court, each question by itself being judged according to its merits and as it appears to C.C.M., who will continue the notes which have been a prominent feature in the past.

The successful competitors in Vol. 22 are:—

First Class.—*First Place:* W. Heys, Huncoat. *Second Place:* F. Hutchinson, Bolton. *Third Place:* F. J. Aston, Haydock.

Second Class.—*First Place:* A. Nelson, Glyn Neath. *Second Place:* J. Grundy, Bryn. *Third Place:* E. Ambrose, Rhostyllen, late of Ponkey, near Ruabon.

Preparatory.—*First Place:* C. Simpson, Usworth Station. *Second Place:* T. Gaskell, Bryn. *Third Place:* J. C. Rodman, Cwm.

Mr. Hutchinson and Mr. Aston may continue to compete in the First Class, but cannot take part in the lower stages. The First Class or Second Class will be open to Mr. Grundy and Mr. Ambrose as heretofore. Mr. Gaskell and Mr. Rodman may compete in any one of the three stages, just as they may decide.

In future competitions Mr. Nelson must confine himself to the First Class, and Mr. Simpson may take the questions in either Second Class or First Class. As to Mr. Heys, it will be understood that he cannot continue as a competitor in any stage, but he may find a sphere of usefulness in solving some of the knotty problems set by readers in the Correspondence columns. For publication in an early issue we shall be pleased to receive a few particulars of the career of Mr. Heys, together with his photograph.

Upon application certificates will be presented to all Competitors who had one or more answers selected for publication in the Prize Competition of Volume 22.

As announced last issue a section for Firemen takes the place of what was known as the Preparatory. We hope that firemen, deputies, or examiners will make the fullest use of their special department in this Competition. Elementary students as stated will find that they are catered for in the new feature to commence early in Volume 23.

We have under consideration the introduction of new subjects for special treatment by experts, and as arrangements are completed announcements relating thereto will be made.

SUBMERGED COAL IN SOUTH STAFFORDSHIRE.

At a meeting of the South Staffordshire and Warwickshire Institute of Mining Engineers, in Birmingham, on the 22nd ult., Mr. J. Meachem, who presided, gave expression to the deep regret felt by the members at the death of the Government mines inspectors and other of their *confreres* who lost their lives in the Cadeby Pit disaster. A vote of condolence with the relatives of those killed was passed by the members standing. In a discussion on the loss of mineral areas in South Staffordshire, Mr. D. E. Parry said every mining engineer would regret that it should be necessary that any coal which could be worked in some circumstances should be left behind. It had been estimated that there were about 40 million tons of coal in the South Staffordshire area which were in imminent danger of being irretrievably lost owing to submergence. Reduced to proper proportions, however, he did not think the estimate was so alarming. The 40 million tons of coal were not in one area intact, but were scattered over a rather large district, being distributed in small and isolated patches here and there about the thick coal portion of the South Staffordshire district. The coal was lost for the present, it was true, but the time would come when circumstances would be more favourable for working it. On the other side of the eastern and western boundaries of the coalfield there were lying untold millions of tons of coal. Although the output of the South Staffordshire district had seemed stationary for some years, with the development going on at Baggeridge and Holly Bank on the western side, and at Aldridge and Walsall Wood on the eastern side, there was an assurance that for a good many years to come there would be a plentiful supply of coal to feed the industries of South Staffordshire.

SOME COLLIERY DISASTERS.

Among the more serious colliery disasters which have taken place in the United Kingdom during recent years are the following:—

1879.—Jan. 13: Dinas Pit, Rhondda Valley, explosion; 63 killed.

1880.—Jan. 21: Layeett, near Newcastle-under-Lyme; about 73 deaths.
Sept. 8: Seaham, near Sunderland; 164 deaths.
Dec. 10: Pen-y-Graig, South Wales; 101 killed.

1883.—Nov. 7: Moor-Fields Colliery, near Accrington; about 68 deaths.

1885.—June 18: Clifton Hall, near Pendlebury; 177 perished.
Dec. 23: Mardy Colliery, Pontypridd, South Wales; 200 men entombed, 81 deaths.

1887.—May 28: Udston Colliery, near Glasgow; 73 killed.

1888.—April 19: St. Helen's Colliery, Workington; about 30 lives lost.

1889.—Oct. 16: Mossfield Colliery, Adderley-green, Staffordshire; 59 deaths.

1890.—April 30: Llancreh Colliery, Mon.; 176 deaths.
March 10: Morfa Colliery, Glamorganshire; 87 deaths.

1892.—Aug. 26: Parkslip Colliery, Tondu, near Bridgend; 116 deaths.

1893.—July 4: Combs Colliery, near Dewsbury; 139 deaths.

1894.—June 23: Albion Colliery, near Pontypridd; about 286 deaths.

1896.—Oct. 6: Micklefield Colliery, near Leeds; 66 deaths.

1905.—July 11: Wattstown, Rhondda Valley; about 120 deaths.

1908.—Feb. 16: West Stanley Pit, North-West Durham; 168 lives lost.
Aug. 18: Maypole Colliery; 76 lives lost.

1910.—May 11: Wellington Colliery, Whitehaven; 140 men and lads entombed, only 4 rescued.
Dec. 21: Hulton Pit, Bolton; 340 lives lost.

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The Science & Art of Mining.

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WIGAN, SATURDAY, AUGUST 3, 1912.

COLLIERY ENGINEERING.

By CLANSMAN.

Parallelogram of Forces.

If two forces inclined to each other act at a point they will produce or tend to produce motion. One force may be substituted which would have the same effect as both of them.

It is called the *resultant force* or simply the *resultant*. The resultant may be obtained by drawing the two forces to scale and constructing a parallelogram of which the two forces so drawn are adjacent sides. If now we draw the diagonal of the parallelogram which passes through the point at which the forces act, this line will represent the resultant, both in direction and magnitude, the sense being *away from* the point. See *Figure 28*.

Equilibriant.—If two forces acting at a point are inclined to each other it is possible to introduce a third force which will neutralise their effect so far as moving or tending to move the point is concerned. Such a force is called the equilibriant. It is equal in magnitude to the resultant, but acts in the opposite direction. The equilibriant may be found in the same way as we find the resultant, the only difference being that we mark the sense *toward* instead of away from the point.

In *Figure 28* a force of 50lb. is represented by *OB* and a force of 40lb. by *OC*, both acting through *O*. *CD* is drawn parallel to *OB* and *BD* is drawn parallel to *OC*, thus completing the parallelogram *OB DC*. The diagonal *OD* which passes through the point *O* represents the resultant. If the forces *OB* and *OC* move the point *O*, then motion will take place along *OD*, and the motion would be just the same as if a single force *OD* had acted. A force equal to *DO* would be the equilibriant of *OB* and *OC*. The reader will have already observed that this agrees with the triangle of forces.

Rectangular Components.—If the parallelogram of forces be a rectangle, *i.e.*, if the two forces are inclined to each other at an angle of 90°, the two forces are called the rectangular components of the force known as the resultant. Any force may be substituted by rectangular components by simply drawing a horizontal line through one end of the line representing the force, and drawing a line perpendicular to this line so as to pass through the other end of the line representing the force.

Polygon of Forces.—If any number of forces which act on a particle form a closed polygon when drawn in succession to scale, the forces are in equilibrium.

If when drawn to scale they do not form a closed polygon, the resultant will be found by joining the starting point to the last point.

Thus *Figure 29* represents forces of 5, 6, 7, 8, 9 and 10lb. acting on a particle at *O*.

Figure 30 is the polygon of forces drawn to scale. To close the polygon a line *ga* of 7 units is required. Hence the resultant is a force of 7lb. acting in the direction *OR*, or *ag* through the point *O*.

Graphic Statics.—The engineer utilises his knowledge of the force polygon in designing structures which are intended to resist a force or a series of forces, even when they do not act at one point. The forces themselves are previously estimated and their line of action obtained. The frame or structure is then so designed that it may resist without injury all the forces acting upon it.

The condition to ensure equilibrium is that the force polygon must close, and if it does not, material must be put into the structure to take up the pull or the push which represents the resultant of all the forces. In other words a member is introduced to provide the equilibriant force. For this reason problems of this kind are called *graphic statics*.

Notation.—In working out problems in graphic statics the student will find it most convenient to use a regular notation to distinguish the various forces dealt with. Thus in *Figure 31* forces of 4, 5, 3 and 6lb. are shown radiating from a point. This is called a space or frame diagram, because it shows the relative position of the forces in space. The best method of naming these forces is to place a letter between each of them, *i.e.*, *A*, *B*, *C*, &c. Thus the force of 4lb. is the force *AB*, the force of 5lb. the force *BC*, and so on. This method is known as *Bow's Notation*. The reader will observe that it is the space in the diagram which is named rather than the force, but the force gets the name of both the spaces which it divides.

Frame and Force Diagrams.—In working out a problem we draw two diagrams. First, the space or frame diagram ; second, the vector or force diagram. The vector diagram is obtained by drawing a polygon whose sides are parallel to the lines in the frame diagram, and equal in magnitude to the respective forces dealt with. Thus *ab* (*Figure 32*) represents to scale the force *AB* in direction and magnitude, *bc* the force *BC*, and so on. The force diagram does not close, and to close it a force equal to *ea* in magnitude and direction must be applied to the central point in the frame diagram. That is, the force *EA* as shown dotted.

Link or Funicular Polygon.—If the forces do not act at one point we can still find the position of the equilibriant or resultant by taking moments of the system of forces round any convenient point. Let *P*, *Q*, *R* and *S* (*Figure 33*) indicate the position of four forces of 3, 4, 6 and 5lb. respectively. Their lines of action do not intersect at one point. First name the forces in the space diagram. $P = AB$, $Q = BC$, $R = CD$, &c. Then draw the force polygon making *ab* = 3lb. and parallel to *P*, *bc* equal 4lb. and parallel to *Q*, *cd* equal 6lb. and parallel to *R*, *de* equal 5lb. and parallel to *S* ; *ea* is the equilibriant.

Now whatever point in space we take moments round the resultant or equilibriant force will be the same. The reader can easily verify this by working an example taking moments round various fixed points.

Therefore take moments round a point *O* anywhere inside or outside our polygon. We have selected the point *O* inside the polygon, as shown in *Figure 33*. Join *ao*, *bo*, *co*, *do* and *eo*.

Now commence at any point on the line of action of the force *P* in the frame diagram, and draw a line in space *B* parallel to *bo*, until it cuts the line of action of the force *Q* ; through this point draw a line in the space *C* parallel to *co* until it cuts the line of action of the force *R*. In the same way draw a line in the space *D*, and in the space *E*. If now a line be drawn in space *A* parallel to *ao* from the starting point, it will cut the line drawn in space *E*. This is a point in the line of action of the resultant. Draw through this point a line parallel to *ae*, and this gives the line of action and sense of the equilibriant *T* in the system of forces given.

In graphing this problem what we really do is to resolve each force into two components which pass through our selected point *O*. Thus the line drawn in space *B* is really a force equal to *bo*, and the line drawn in space *C* is really a force equal to *oc*. By vector addition we know that $bo + oc = bc$, that is to say, the forces *bo* and *oc* have exactly the same effect as the force *Q* would have, and they pass through the point *O*.

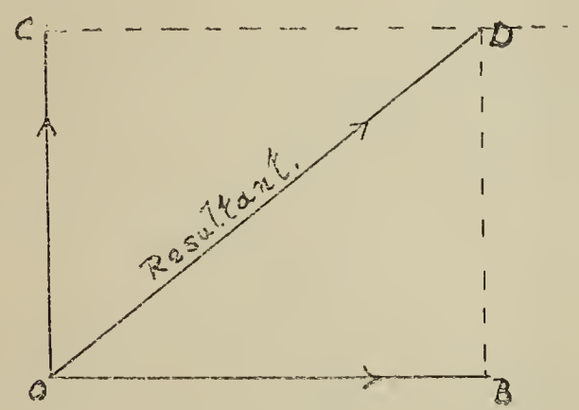


Figure 28.

This is called a *link or funicular polygon*, because the lines drawn in the spaces in the frame diagram give the correct relative positions of a series of links which might be introduced to resist the action of the forces given.

Note that for equilibrium it is essential that the polygon of forces is a closed figure, and also that the link or funicular polygon is also a closed figure. Referring to the link polygon

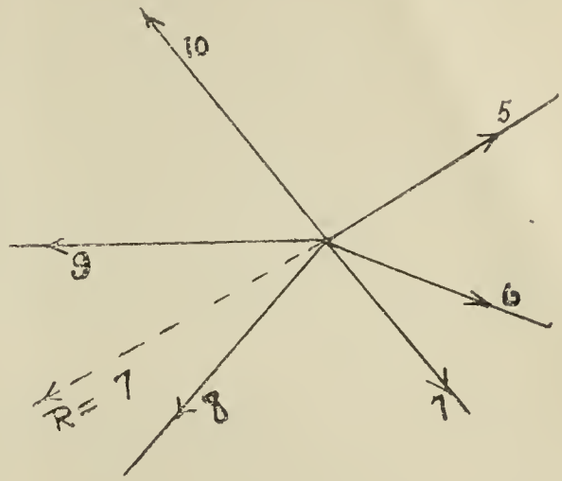


Figure 29.

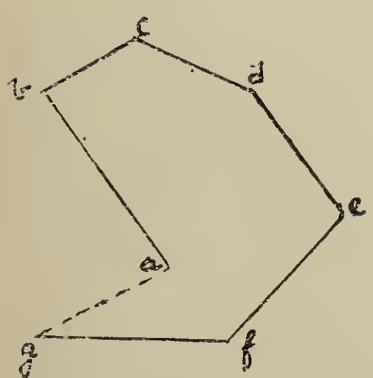


Figure 30.

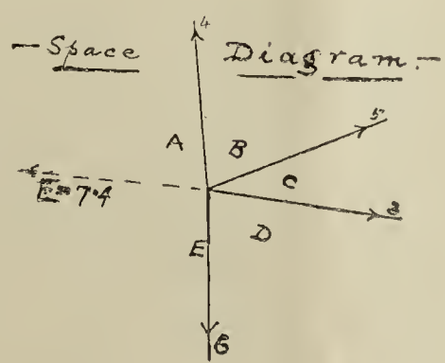


Figure 31.

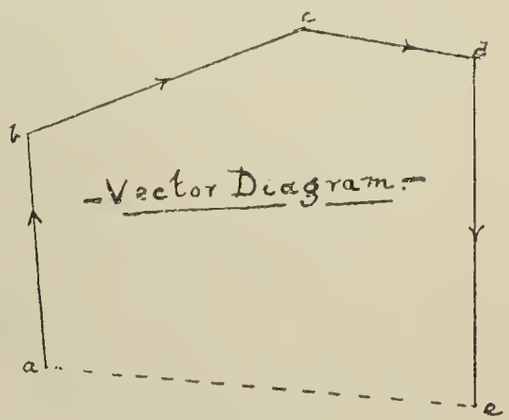
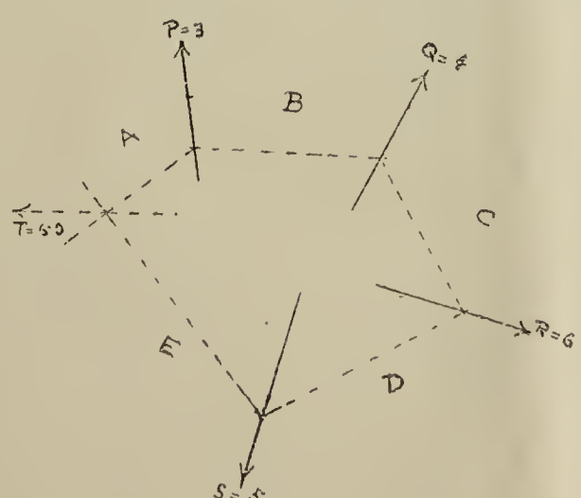


Figure 32.



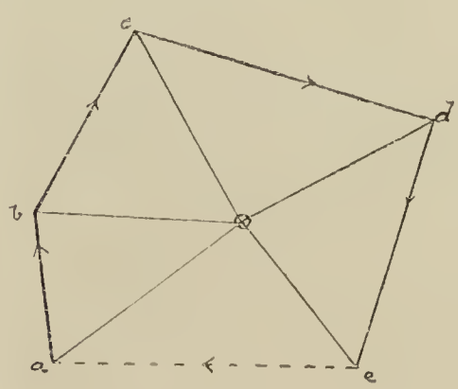


Figure 33.

In this way we get the components

$$ao + ob = P$$
$$bo + oc = Q$$
$$co + od = R$$
$$do + oe = S$$
$$eo + oa = T$$

in *Figure 33* note that it might happen that the link in space *E* would be parallel to the link in space *A*. In that case they would never meet, and the system of forces would be equivalent to a couple whose magnitude would be equal to the component *oa* multiplied by the perpendicular distance between the parallel lines.

HYDRAULIC STORAGE AT DALZELL AND BROOMSIDE COLLIERY.*

A portion of the Wishaw Coal Company's leasehold at this colliery lies along the banks of the Clyde, and as the surface is the old course of the river, the greater part of the area is covered with a bed of water-bearing gravel. The main seam, 25 fathoms below the surface at this point, has been worked out into stoops about 20 yards square. The management were faced with the necessity of abandoning the coal in the stoops (fully 50 per cent. of the coal in the solid seam), or of working out these stoops, the effect of which, by ordinary methods, would be to cause a rapid subsidence with consequent breakage of the roof, and result in the flooding of the workings, and create a constant menace to those in the deeper seams over the whole of the area of the Company's property. This being so, the owners, advised by their mining engineer, Mr. R. W. Dron, decided to extract the stoops and fill the waste with redd from the refuse heaps on the surface, by means of the hydraulic stowage system. Mr. Dron was of opinion that the coal could be worked by this means, and the quantity of water to be pumped with it would not exceed the capacity of the pumping plant which was already installed.

The seam in question is 4 feet thick, and has a strong post or rock roof and a blaes floor. The dip of the strata is 1 in 8 to the south-west, and fairly regular. A large heap of washer *debris*, consisting of burnt shale and fire-clay, was ready at hand on the surface, and this probably makes the best material possible for hydraulic stowing. The clay and shale dirt of the heap is hand-filled into a canvas belt, and is carried by it to a cross conveyor, which delivers into a jigging screen with 1½-inch mesh set above the dirt heap. The material which does not go through the screen passes on to a crusher in which it is reduced to the requisite size. The dirt passes from the screens into a large hopper 30 feet square, tapering towards the bottom, into a shoot provided with a door to stop and regulate the flow of dirt. Perforated pipes are carried round this hopper, and a constant flow of water is kept playing on to the *debris* and the inside of the bin, and these keep the material moving down the receiver as it drains off through the shoot at the bottom. The dirt from the shoot then passes into a concrete mixing chamber 3 feet in diameter, and provided on each side with a 6-inch perforated water pipe, so placed that two rows of water-jets play on the dirt as it falls from the shoot, and so cause it to be carried into the pipes and to the working face underground.

One man is employed at the shoot and mixing chamber regulating the flow of dirt and water; there is telephonic communication between this man and the working place underground. Two men are employed about the screens and bin, and four filling dirt on to the belt conveyor. A length of 6-inch diameter pipe, connected to the same supply as the mixing water pipes, enters the main pipe line at a point beyond the mixing chamber so as to provide an extra flushing supply of water if required. Some trouble is experienced owing to the pipes on the surface being choked, the reason being that the dip of the pipe line on the surface could not be made more than 1 in 40. The pipes carrying the material and water are cast-iron, "spiggott and faucet" jointed, but flanged pipes are used as every fifth pipe, in order to facilitate opening up the columns in the event of a stoppage. The pipe line is carried down one of three bore-holes to the workings of the main seam underground; one of the other two bore-holes is used to carry the electric cables underground for the pump, and the other for the discharge column of pipes returning the used water to the surface. The water-carried dirt passes through similar pipes to those at the surface until the actual working face is reached, where it enters a column of wrought-iron pipes, $\frac{3}{16}$-inch thick, of the same diameter as the cast-iron pipes. These pipes are the columns for the face, and are screw-jointed, but the thread on the end of each thimble nearest to the face nozzle is turned off so that the upper end of each pipe fits easily into the lower end of each thimble, and the last pipe on the column can be easily detached by an upward and outward motion from below. The working face consists of four stoops with the roads between them, amounting in all to a straight line of 260 feet to the full dip of the strata. This face was prepared for the first stowing by a building 30 feet wide being erected on the low side, but since work has been in progress it has been found that little or no pressure falls on the low side buildings, so these are now only built 6 feet or so wide. Rails for tub roads are laid down the face, connecting the drawing road at the upper end to the drawing road at the lower end of the face, as in the "Nottingham" system of working, and the tubs are brought down these rails to a point near the miner working the coal from the stoops. The miner fills them, and they are taken down the face road to the lower drawing road, and so out to the main haulage.

An ingenious method of letting the full tubs down the face is in operation. A single rope is laid down the face by means of which a bogie attached to the rope by a clip collects the tubs filled by the miners and lowers them to the drawing road. No trouble has, so far, been experienced from the miners in the upper part of the face having their tubs ready before those at the lower part, although each party of two miners works independently. The management wished the miners to work in parties of twelve or so at the commencement of the work. They refused to work together this way, but promised to keep the filling similar and regular.

The timbering at the face is done with half-round bars supported on two props set at right-angles to the face of the coal, but additional props are also set wherever required. The face pipe line is carried on pairs of props as near the roof as possible, supported by a wooden strap nailed to each prop; the end of each pipe, up the hill, is fitted with a wide long pair of glands, which allows the supporting props to hold the pipe close to the pipe above it. This pipe is carried about the centre of the width (here 14 feet) which it is proposed to stow. After the face has advanced sufficiently to allow stowing 14 feet in width to be put in, a line of props about 4 inches in diameter is set as near the face as is convenient, and on to these are nailed wooden laths, 3½-inch by ¾-inch, to hold the brattice cloth, which is nailed over them from roof to floor. The object of this cloth is to hold the dirt or silt forced in to the waste, and also to allow the water which carries it to drain off as speedily and as completely as possible. Some difficulty was experienced in obtaining cloth of a suitable texture for this purpose, but eventually a cloth was procured somewhat more open than the cloth usually used for ventilation, and this gives excellent results.

The leading man of a gang of three stands at the top end of the last pipe, and directs the man at the dip heap on the surface when to allow dirt to flow and when to stop; he instructs the men with him when to withdraw timber and when to pull the pipe he has knocked out away from the filling waste. This man stands in water, and has altogether a very wet and dirty job, but the Company provides him and his men with everything likely to improve matters, and they do not complain of the conditions. The force of the water carries the dirt 8 feet or 10 feet from the pipe ends and packs it tightly into the waste. The water drains off through the cloth screen filter, and leaves the sediment almost a solid mass up to the roof of the place. As the stowing comes up to the pipe the man at the pipe withdraws the props under the last pipe and draws out the pipe, which is pulled away by the men behind by means of a rope previously attached. Three men can stow eight pipe lengths (24 yards) in eight hours, but three other men are required in the previous shift to brush and wall the roads (the walling on the lower side is essential) and to take out timber wherever possible, and also to move the line of rails nearer the coal face. Having given up its dirt, the water is carried by drains at the roadside back to a sump (which was made when the work commenced, and has not yet been changed) below the lower road, passing through several settling tanks before reaching it. Clean water for the return pump is essential, but in spite of every precaution, the water returned still carries a quantity of the finest silt.

The pump in use is a five-stage "Mather and Platt" turbine pump, working with a head of 170 feet at 145 revolutions; the motor, 86 amperes, three-phase current at 400 volts. This pump has proved very successful, and if it does not draw air into the suction, works very well, even when pumping very dirty water. The return column is composed of wrought-iron 6-inch diameter pipes, and is taken up the third bore-hole to a settling

* From Mr. W. Walker's annual report on Mines and Quarries in the Scotland Division for 1911.

pond, 15 feet above the mixing chambers. The head of 15 feet is found to be sufficient, but it is absolutely essential to have a large quantity of water in the pond ready for use.

The distance that the strata have subsided, in the area worked during the year ending last January, measured underground, is 2½ inches. An elaborate system of measurement of cross levels has also been organised on the surface, and these show a subsidence equal to about 20 per cent. of the thickness of the seam.

From a mining point of view the system appears most successful, as no work in it is very difficult or highly technical, and the cost in unworked areas, where old roads have not to be stowed, will compare very favourably with other methods. There is little doubt that the regular and gradual subsidence which would take place over areas worked in this way does not cause the surface damage which takes place where other methods are employed, as the stowing is absolutely uniform and no coal or timber is left in the area from which the coal is extracted.

CORRESPONDENCE.

Information Wanted.

To the Editor of The Science and Art of Mining.

SIR,—Will some reader kindly answer the following problem :—

There are 25,000 cubic feet of air in the return air-way, containing 2½ per cent. of gas. Find extra quantity required to reduce the gas to 1½ per cent.

Yours, &c., S. J. J.

To the Editor of The Science and Art of Mining.

SIR,—A great deal of confusion existed not long ago in a fireman's class in connection with the correct answer to the question given below; could any kind reader or TYKE please insert the correct solution on sound reasonings in your interesting Journal, and by so doing relieve many minds :—

Q.—How much fire-damp would have to be given off to foul a current of 6,000 cubic feet of fresh air per minute to such an extent that the air will contain 2 per cent. of gas ?

Yours, &c., WELSHY.

To the Editor of The Science and Art of Mining.

SIR,—Will TYKE or any reader answer the following question for the benefit of a few readers in this district :—

A goaf, 1,000 cubic yards in area, is filled with fire-damp, the barometer being 30 inches. The barometric pressure then changes at a regular rate in one hour from 30 to 29 inches. The current of fresh air entering the district is 1,000 cubic feet per minute. What would be the percentage of fire-damp in the air during the hour, after passing the goaf ?

Yours, &c., C. E. S.

To the Editor of The Science and Art of Mining.

SIR,—As an amateur geologist I would be pleased for answers to the following :—

(1). Describe the rocks which you would expect to find near the junction between a great intrusive mass of granite and beds of argillaceous rock.

(2). Describe the various indications of intense crushing action which may sometimes be found near fault planes.

Yours, &c., MORGANWG.

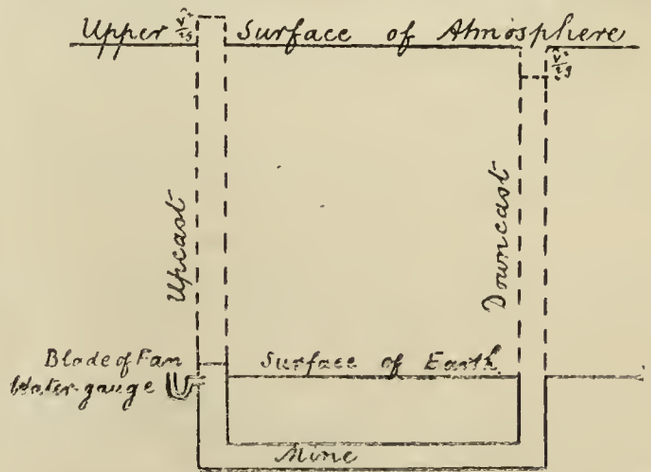
[TYKE will answer the above questions as time and space permit.]

The Theory of the Fan.

To the Editor of The Science and Art of Mining.

SIR,—After further consideration I find that I have made a mistake in my investigation of the fan. For the purpose of giving a graphic idea of the increase in pressure caused by a revolving fan I said that when the fan begins to revolve a column of air is raised and continues to rise until the top of the column stands $\frac{V^2}{g}$ feet above the level of the upper surface of the atmosphere. This is not correct. I should have said that when the fan begins to revolve a column of air is raised, and it continues to rise until the top of it stands $\frac{V^2}{2g}$ feet above the upper surface of the atmosphere, while in another part of the plain a corresponding column begins to sink, and continues to sink until the top of it is $\frac{V^2}{2g}$ feet below the general level. (See sketch).

I have already shown that the blade of a fan moving at V feet per second can support a column of air $\frac{V^2}{g}$ feet high by virtue of its own motion. Now we must remember that the moving blade has a two-fold effect upon the air in contact with it. The blade has two faces; we will call the one the leading face and the other the following face. The air in contact with the leading face is compressed, but the air in contact with the following face is rarefied. Now, if a gauge were placed so that one leg were connected with the air over the leading face, and the other leg were connected with the air over the following face, the reading of the gauge would be $\frac{V^2}{g}$. This is what is called the theoretical depression created by the fan, and this is the formula to use when the theoretical water-gauge



is to be ascertained. But the gauge is generally placed so that one leg is connected with the atmosphere, and the other leg either with the air over the leading face or with the air over the following face. If the gauge be placed in this way the reading would be $\frac{V^2}{2g}$. By using this formula we get approximately the observed water-gauge of a fan with radial vanes.

Let A be the height of the atmosphere in feet, then A also represents the pressure of the atmosphere measured as a column of air. When the fan is at rest the pressure on both faces of blade is A, and of course the water-gauge stands at zero, but when the fan is in motion the pressure on the leading face is $A + \frac{V^2}{2g}$ feet of air, and the pressure on the following face is $A - \frac{V^2}{2g}$ feet of air. From this we see that the fan can support a column of air $\frac{V^2}{g}$ feet in height by virtue of its own motion, and also that the effective pressure as calculated from the observed water-gauge should read approximately $\frac{V^2}{2g}$. The observed water-gauge of a fan with radial vanes should be one-half the theoretical water-gauge. The ratio between the observed water-gauge and the theoretical water-gauge is called the manometrical efficiency of the fan, and its numerical value varies from ·4 to ·7 according to the construction of the fan.

Yours, &c., W. GRIEVE.

PRIZE COMPETITION.

" Worth makes the man, and want of it the fellow,
The rest is all but leather or prunello."

Regulations for Volume XXIII.

This competition is open to all who have not secured first place in Honours or First Class in earlier volumes. Competitors need not take the same stage every issue, but answers to questions in more than one stage in one issue cannot be recognised. The selected answers will be published, and the successful competitor for each question will receive a Prize of 2s. 6d. The questions set will be taken chiefly from Examination papers under the Examination Boards throughout Great Britain and the Colonies.

Each answer (with the question attached) must be written on one side only of separate sheets of paper, bearing the full name and address of the sender, the top left-hand corner of the envelope to be endorsed *Competition*. All accompanying sketches must be in good Indian ink, no colouring or wash, and on white unruled paper, separate from the manuscript. Lettering on sketches should be bold and clear.

Marks will be awarded. The SELECTED PUBLISHED ANSWER will possess a value of *15 marks;* whilst to the remaining answers for competition will be given a value in marks according to merit, the number of marks being clearly shown. The names of Competitors who are awarded marks are appended to each answer. In the event of two or more competitors having the same name they will be distinguished by the addition of the town or village.

The Competitor in each stage who secures most marks throughout the volume will be held to be the winner in that stage. In deciding this the question whether Competitors' answers have been published will not be considered, the award being regulated by the aggregate marks secured. Each winner will be entitled to and receive the Publishers' Book Prizes, value not less than one guinea, whilst the photo of the successful First Class competitor will be published, and he cannot take part in the Competition of later volumes.

In addition to the foregoing, the Editor will give special prizes to the Competitor in each stage who has the largest number of published answers throughout the volume, the value in case of the Editor's prize being not less than one guinea each.

To every sender of published answers we shall present at the end of the volume, on application, a handsome specially prepared Certificate.

All answers to the first set of questions given in this issue must be addressed The Editor, *The Science and Art of Mining*, Rowbottom Square, Wigan, and be received not later than-

Tuesday, August 20th, 1912.

Unless the conditions are strictly complied with, competitors will be disqualified. Our decisions are final, and we cannot enter into correspondence regarding these decisions. SPACE IS LIMITED, AND UNDULY LONG ANSWERS CANNOT BE GIVEN A PREFERENCE IN SELECTION.

—READ THIS: IMPORTANT REGULATION.—

Original answers are specially desired. No contribution whatever to these columns will be published unless (1) the Competitor states at the foot of the answer that it is his own original composition; (2) quotes in the course of the answer the source (with name of author) from which any portion thereof has been copied. This regulation must be adhered to in all cases—books, papers before Institutes and Institutions, and Journals. If Competitors have been helped by more than one authority the full title of each work, with the name of the Author, should be given, also, if possible, the chapter and page of the volume, preferably in that portion of the answer to which reference is made. Competitors sending in as their own composition matter extracted from text-books, &c., will, upon such breach of this regulation coming to our notice, be named in these columns, and debarred from all future competitions.

Questions for Mining and Engineering Students.

[*The selected answers to the following questions will appear, not in No. 1, Vol. XXIII., but in No. 2, Vol. XXIII.*]

FIREMEN.

Q. 1. MISS-SHOTS.—*Describe carefully but briefly how you would proceed in case of a miss-shot.*

Q. 2. PRACTICAL WORKING.—*Describe with sketches how you would proceed to open up an old road for haulage purposes.*

Q. 3. HAULAGE.—*Give sketches and description of tightening carriage for an endless-rope system of haulage.*

SECOND CLASS OR UNDER-MANAGER'S.

Q. 4. UNDER-MANAGER'S DUTIES.—*Describe, entirely in your own words, the principal duties of an under-manager.*

Q. 5. COAL-CUTTING MACHINERY.—*Give a simple sketch and description of a coal-cutting machine.*

Q. 6. PUMPS AND PUMPING.—*Give sketch and description of a three-throw pump to deal with 5,000 gallons per hour to a height of 600 feet.*

FIRST CLASS OR MANAGER'S.

Q. 7. HEADINGS.—*Explain clearly how you would set out a heading underground to the bearing of N44·21E, to rise 1 in 3.*

Q. 8. EXPLOSIONS.—*What would be your first steps in case of an explosion underground?*

Q. 9. FANS.—*Give a sketch and description of a Waddle fan.*

Best Answers Received to Questions in No. 24, Vol. XXII.*

With Notes by C.C.M.

PREPARATORY.

Barometers.

Q. 1.—*Describe the principle of the barometer.*

A.—It is said to be the mystery connected with the ordinary suction pump that led to the discovery and principle upon which the barometer acts. As water will rise in an ordinary suction pump to a height approaching 33 feet under ideal conditions, it was said that the reason for this was that nature abhorred a vacuum to 33 feet and no further. It was in order to find a satisfactory answer to this that the famous scientist Galileo made experiments, the result of which was to establish that air has weight and is subject to the great law of gravitation. These researches were then taken up by Torricelli, and it was he who discovered the instrument by which this weight could be measured. From this he made it clear that water rose 33 feet, not because nature abhorred a vacuum, but because a column of water at that height just counterbalanced the weight of the atmosphere. There are at least two varieties of the barometer, the aneroid and the mercurial; as it is the latter which is installed on the surface at the mine, this will be the one that will be described. The principle of this barometer is as follows: If a tube about thirty-three inches in length and closed at one end be filled with mercury, the open end closed with the thumb, and the tube inverted into a basin of mercury, *all* the mercury will not run out of the tube into the basin of mercury, even if the thumb be withdrawn, provided always the open end of the tube is kept below the surface of the mercury, but some of it will remain in the tube, forming a column of mercury rising 30 inches above the surface of the mercury in the basin. A similar experiment carried out with a tube containing water instead of mercury, would show that the water would be maintained at a height of about 33 feet. The liquids in both of the tubes are kept up by the pressure of the atmosphere on their surface. This being so, any variations in this pressure will affect the height of the liquids in the tubes. If the air becomes lighter the mercury will fall; if it becomes heavier the mercury will rise. It will thus be seen that the mercurial barometer acts on the principle of balancing the weight of a vertical column of the atmosphere, such a column having a base precisely the same in area as that of the mercurial column.

We have spoken of the air having certain weight, and thus exercising a pressure, but it must be clearly understood that the weight at the level, for example, depends on the enormous mass of superincumbent air. The air below is pressed upon by the air above, and therefore becomes heavier and denser. The barometer at sea level usually stands at 30 inches, but at a height of 18,000 feet a column of mercury 15 inches long will balance the weight of the atmosphere. The pressure here then is only half that at sea level, due to the shorter column of air acting on the mercury. The barometer must be placed in

* The names and addresses of competitors who stated at the head of their answers that they were original appear in italics. In the case of remaining answers the source is stated from which competitors have quoted any part thereof. Competitors should notice the Important Regulation in preceding column, which will be strictly enforced.

a conspicuous position near the entrance of the mine to comply with the C.M.R.A. Its purpose is to indicate the variations of the atmospheric pressure, as this is closely related to presence of gases in the mine. On high readings the gases are held back by the increased pressure, but on a fall of the barometer this pressure is reduced, and they expand and find their way into workings of the mine. As gases are extremely sensitive to pressure it sometimes happens that a reduction can be noticed in the mine before the barometer shows it on the surface. The importance of the barometric pressure is not its actual height, but its probable course is what matters in mining operations.

I have been assisted by TATE'S *Mining* and a past issue of this Journal.

J. H. MOORE, The Mills, Gelli-Groes, near Newport, Mon.

Robert Brettell, T. Evans, Junr., A. Champkins, Robt. Benson, W. J. Jenkins, John Taylor, J. E. Tredgold, Jos. Langford, D. Bloore, Geo. Davies, A. E. Helps, Thos. Gaskell, Fred Cooke, W. Randle, Joseph Taylor, J. C. Rodman, T. Garbett, Ben. J. Noot, D. J. Jones, John J. Staley, B. W. Wheeler, Frank Poole, J. H. Spencer, Wm. Williams, T. G. Lippitt (*12 marks each*).

L. J. Thomas, Jas. Bradshaw, D. McBurnie, M. Shaw, Robt. C. Mears, T. D. Edwards, J. Bastow, G. N. Lance (*8 marks each*).

E. Rowney (*4 marks*).

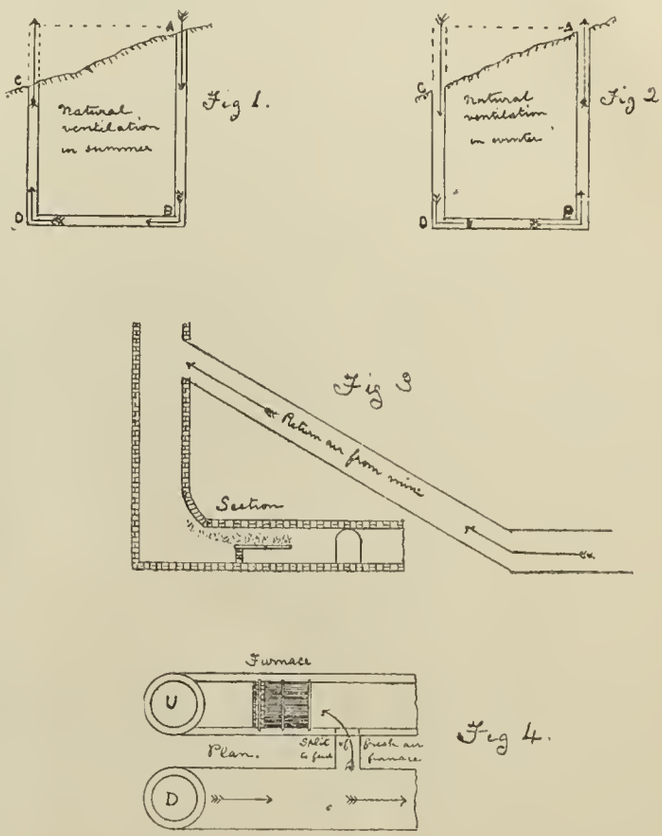
Ventilation.

Q. 2.—*How is an air-current produced?*

A.—To produce a current of air in a mine it is necessary that two air-ways be made for the inlet and outlet of the air, generally termed among mining men as *intake* and *return* air-ways. To ventilate a mine a current of air is caused to flow in at the intake air-way, emerging at the return air-way. In *all* cases this current of air is produced by reason of a difference of pressure between two points, *i.e.*, the intake and return air-ways. This difference of pressure may be caused by several means, either naturally or artificially, the air always flowing from the region of greater pressure to that of lesser pressure in its effort to establish a balance between the downcast or inlet shaft and the upcast or outlet shaft, *and so long as this difference of pressure exists between the shafts so long also will a current of air be produced*, provided of course the communication between the shafts is kept open. As before stated, the difference in pressure may be caused by different agencies, much depending on the amount required to ventilate a mine, together with the depth and the nature, fiery or otherwise. Generally speaking, the means adopted to produce the difference of pressure are: (1) By natural ventilation; (2) by furnace; (3) by fan.

By natural ventilation a current of air is produced to a limited extent, dependent upon the difference in depth, or surface level of the shafts or openings of the mine, and also a difference in temperature of the mine air and the outside atmosphere. When a mine is ventilated by natural means the surface temperature is the principal means of producing the air-current. Taking the average temperature to be about 50° Fahrenheit at a depth of 90 feet, the temperature increases 1° Fah. for about every 60 feet below this point, and as this is practically constant the year round the shafts will be warmer or colder than the surface, according to the conditions prevailing during the winter and summer seasons. Another factor assisting natural ventilation is that air in passing through the workings of a mine is increased in temperature by the natural heat of the strata, the combustion of lights, and the heat arising from the bodies of men and animals, becoming lighter in consequence. Natural ventilation is only suitable for shallow mines of a non-fiery character, being fluctuating in volume, and also liable to reverse according to the temperature at the surface. *Figure 1* is an example of a mine ventilated by natural means, arising from a difference of surface level, the heat of the mine, and from the workers therein, this example showing the course the air circulates in summer. *Figure 2* shows the course of the air in winter. Warm air is lighter than cold air, consequently in summer the surface temperature at *C* being greater and the air lighter than in the shaft *AB*, the air circulates as indicated by the arrows in *Figure 1*. Exactly the opposite occurs in winter, the air at *C* being colder and denser than in the shaft *AB*, thus causing the air to reverse and flow in the direction denoted by arrows in *Figure 2*.

For mines in which natural ventilation is insufficient or unsuitable, the air-current is generally produced by means of a furnace or fan. Where a furnace is employed, it consists of a large fire which is kept burning at the bottom of one of the shafts, the upcast. In some cases where the mines are of a non-gaseous character, the air is made to pass through and over this fire, resulting in the air becoming vastly increased in temperature. Consequently the furnace creates a difference of pressure between the air in the upcast and the downcast shafts, by reason of the difference of *temperature* prevailing in the respective shafts consequent on the heating of the air passing over the furnace. In mines of a fiery nature, where a furnace is used the return air must (to comply with the C.M.R.A.) be carried clear of the furnace by means of a dumb-drift or air-way. This dumb-drift communicates with the upcast shaft a distance from the bottom. The air on entering the upcast is greatly heated by the products of combustion from, and the general heat set up by, the furnace below. *Figure 3* shows section of furnace and dumb-drift, and *Figure 4* shows plan of furnace.



Illustrating Question 2.

In our modern mines the air-current is produced by means of centrifugal fans. BRYCHAN in his notes (Vol. 21, No. 21) says: "Centrifugal means *flying from a centre*. A centrifugal fan may be defined as a wheel which, when revolved, causes the air at its centre to move in as straight a line as possible to its periphery or circumference, there to be thrown off at a tangent to the circle in which the fan blade tips move. More air will rush in to occupy the space which has just been vacated, to be in its turn thrown off at the periphery as before. It follows therefore that if the fan centre be placed in communication with the mine, and the fan made to revolve, the tendency will be to create a partial vacuum in the fan centre, towards which the mine air will move in order to establish equilibrium. This, as long as the fan revolves, cannot be established, and therefore a current of air is made to circulate owing to the heavier air in the downcast shaft pressing forwards right through the mine in its efforts to reach the region of reduced pressure, *i.e.*, the fan centre." This kind of fan is sometimes termed "exhaust" fan, being in general use in this country with very few exceptions. Compressive, or forcing fans may also be used to produce a current of air. This is brought about by the fan forcing or compressing air into the downcast shaft, thus causing

a difference of pressure over the air in the upcast shaft; therefore the current flows down the shaft into which it is compressed, circulates through the workings, being heated by the strata, &c., thus becoming lighter, finally rushing up the upcast shaft, consequent on being unable to resist the greater pressure of the air in the downcast shaft. Thus it is seen that whatever means are employed to produce a current of air in a mine, all amount to the same thing in the end, viz., a difference of pressure in the air at the inlet and the outlet.

T. Garbett, 160, Wigan Road, Atherton.

[Note.—An air-current is produced by a reduction of pressure in one place, or any increase of pressure in another. When we use an exhaust fan we reduce the pressure in the fan drift below that of the atmosphere, and the result is that the difference of pressure causes a current of air to pass down the downcast and eventually up the upcast. If we use a blowing fan we increase the pressure in the downcast to above that of the atmosphere, the result being the same as in the other case. If we ventilate by means of a furnace we heat the air in the upcast, thereby making it lighter than the atmospheric air, and a current of air is again obtained. Air currents on the surface, or winds, as they are called, are caused by a reduction or increase of atmospheric pressure in one place as compared with another, the result being a flow of air towards the district of lower pressure in an endeavour to restore the balance of pressure. Cold air being heavier than hot, the wind will generally flow from a cold district towards a warmer, and thus winds have generally a cooling influence. Winds are very often followed by rain, because cold air will not contain as much water vapour in suspension as will warmer air, and a cooling of the atmosphere causes condensation of the water vapour, the result being rain.—C.C.M.]

John Taylor, Jas. Bradshaw, J. H. Cumberbatch, Albert E. Helps, Daniel Bloore, B. W. Wheeler, Albert Whittingham, Wm. Williams, David McBurnie, Thos. Gaskell, Wm. Randle, Jos. Taylor, Jos. C. Rodman (*12 marks each*).

J. E. Tredgold, Geo. Davies, Ernest Rowney, L. G. Thomas, Frank Poole, John Ellis, Matt. Shaw, Albert Wright (*8 marks each*).

T. D. Edwards (*4 marks*).

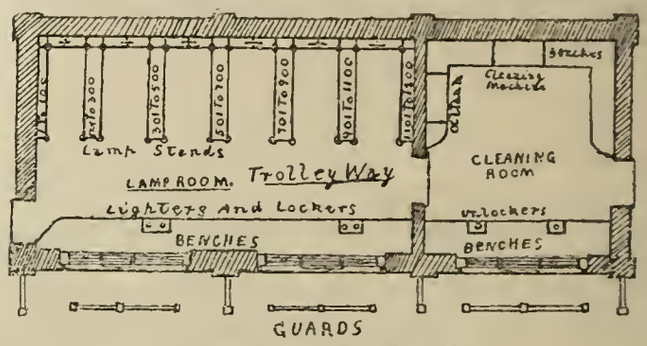
Lamp Rooms.

Q. 3.—*Give a general description of the lamp-room fittings, cleaning and repairing of safety-lamps.*

A.—In fitting out a lamp-room it is necessary to have the benches placed near to the windows to save labour as the lamps are handed in at the windows. The lamp-man not having to move far between the window and the bench will be able to handle the lamps almost as quickly as they are handed in. A good general description of a lamp-room fittings is to have all lamps handed in at one window at the end of the house. They can then be unlocked, and the oil vessels filled at one bench. The rest of the lamp can be taken to pieces and passed over the cleaning brushes and put together again, after which the tops and the oil-vessels can be placed on a trolley and taken to numbered stands. Here the oil-vessel is placed in front and the top portion of the lamp behind. Each stand should be made of iron, and a good idea would be to have four shelves in each, each shelf having place for twenty-five lamps, thus making 100 lamps on every stand. The stands could be arranged in pairs, consequently there would be 200 lamps in one section, all of which could be given out through one window. Each lamp should be locked immediately before it is handed out. In some cases the lamps are all lighted simultaneously whilst on the stands, by means of an electric spark arrangement, but generally each lamp is lighted by whatever means may be employed in that particular lamp-room immediately before delivery to the miner.

The fittings required in a lamp-room in order to arrange the working in the manner described are: In the cleaning room —Unlockers, benches, oil tank for filling, lamp cleaning machine. After cleaning and filling the lamps are placed on the trolley, and taken to their respective stands in the lamp-room proper. Fittings in the lamp-room—The stands as described before, if lamps are lighted singly, benches, lighters, lockers. Where all are lighted simultaneously whilst on the stands only the lockers would be required.

Cleaning and Repairing.—When the lamps are deposited in the lamp-room they are at once examined as to their condition, and if they have been subject to rough usage and damaged whilst in the mine it is reported on so that the damaged part can be repaired before the lamp again leaves the lamp-room. After unlocking the lamps the process of cleaning them commences. The general plan is to have a machine to perform the work of cleaning, and this machine should be provided with a suction fan to carry off the dust from the brushes, thus adding to the comfort and health of the lamp-room staff. The machine consists of a number of brushes which are constantly kept revolving by belting driven generally by a small engine, the brushes being of such shape and size as to allow for the cleaning of every part of the lamp. Fittings are attached to the machine to facilitate the work of separating the various parts of the lamp. The cleaning and trimming are two important features with safety-lamps. If they are not carefully attended to the lamp becomes unreliable and the light given out becomes poor. Any defects on a lamp must be carefully sought out and repaired before the lamp is placed on the stands. A chance blow



Illustrating Question 3.

in the mine may slightly chip the glass, and cause the lamp to be unsafe, and the glass of such a lamp should be changed before it is again taken into the mine. The gauzes may become dented, or perhaps a blow from a pick or some sharp stone may pierce them. Such things as this should be repaired before the lamp is put away in readiness for the miner, and all repairs should be carefully executed.

The accompanying sketch shows the plan of the lamp-room, fittings, &c., as described. The different fittings are named on the sketch. The stands are shown to have room for 1,200 lamps. In the benches there should be a few sliding drawers in which to store repairing materials and tools, to have them at hand in ease of need.

Indebted to Boulton's *Mining* for sketch; also slightly assisted by the study of the same in compilation of the answer.

Wm. Williams, 28, Curre Street, Cwm, Monmouthshire.

Jos C. Rodman, J. H. Cumberbatch, Wm. Randle, J. E. Tredgold, Thos. Gaskell, David McBurnie (*12 marks each*).

John Taylor (*8 marks*).

Explosives.

Q. 4.—*How would you use gunpowder in wet places?*

A.—The use of gunpowder in wet places as an explosive will require special attention owing to the fact of its being reduced in value to a considerable extent when in a damp or wet state. The dangers arising from the use of gunpowder in wet places are not so manifest, seeing that coal dust and fire-damp are not present, thus I would endeavour to get the best possible effects by preventing as far as possible the explosive from getting wet during the process of steuming, &c., so as to prevent miss-shots. Gunpowder as a blasting agent was I believe one of the first explosives used in this country; at the present time it is used very largely in the shallow wet mines of Scotland that are free from fire-damp and coal dust. Gunpowder in itself is very cheap, slow in its action, which makes it suitable for blasting in coal and soft rocks. Due to its being slow in action, it produces a rending force which does not shatter the material being brought down, but prodnces a maximum amount of round coal or shale as the case may be.

Gunpowder, where it is permissible, as a blasting agent has no superior, yet in wet places it may have many disadvantages, being easily rendered defective by water, which may result in hang-fire, or miss-shots, which are exceedingly dangerous.

The original method of using gunpowder which characterised its early use was that the men themselves made their own cartridges the required size, thus being left to their own discretion. In other instances the gunpowder could be purchased in a compressed form, the cartridges being of a circular shape with a conical hole running through them. The original method of firing them was by means of straws, squibs, and the ordinary safety fuse. This method would produce a great percentage of miss-shots and hang-fire shots, owing to the fact that the water would affect the fuse and explosive in many instances, due to them not being made water-proof.

In order to prevent hang-fire or miss-shots, which I believe to be the chief danger arising from the use of gunpowder in wet places, I would use it as follows :—

Only in water-proof cartridges. These can be obtained in specially prepared parchment cartridges, made water-proof by a coating of wax, gutta-percha, paint, grease, &c. The principal thing in wet places is to keep the explosive from getting damp or wet, which can be accomplished to a great extent by using the gunpowder in water-proof cartridges.

I would fire the explosive under the above circumstances by electricity only. This method of firing will do away with the possibility of the fuse being affected by the water. As is well known, ordinary safety fuse is liable to be affected by the water during the process of stemming, which may lead on to serious consequences. By firing the gunpowder with electricity there is less likelihood of hang-fire and miss-shots, because the detonator wires are not affected by water.

An advantage, and one which I have found to be favourable for preventing the gunpowder from getting contaminated with the water at the end where the detonator is inserted into the charge, is to apply a quantity of ordinary tub grease to this end.

In conclusion, I would use copper appliances for stemming, and never apply any undue pressure to the charges when inserting them into the shot-holes. I would comply with the C.M.R.A. relating to shot-firing when using gunpowder in wet places, and take the same precautions as if I were using permitted explosives.

Thos. Gaskell, 138, Downall Green Road, Bryn.

B. W. Wheeler, Wm. Williams, Jos. C. Rodman, Robert Brettell (*12 marks each*).

George Davies, J. Bradshaw (*8 marks each*).

SECOND CLASS.

Pumps and Pumping.

Q. 5.—*What advantages has the plunger over the bucket lift?*

A.—The plunger pump as employed in mine shafts can claim superiority over the bucket lift for many reasons. The following may be mentioned :—

1.—The plunger is not so liable to get out of order ; being more rigid and stronger than a bucket lift it is better fitted for such rough work.

2.—If, however, any part fails at any time its shortcomings and position of same are quickly located ; also repairs can be done more rapidly and effectively, on account of the better facilities afforded for repairs, a state of conditions not always recognised in mine shafts.

3.—In the case of the forcing or plunger pump the total weight or pressure of the water column bears upon the stationary stuffing-box and gland, through which it works. This is an important advantage, because in the case of the bucket lift the whole pressure of the water is upon the movable valve.

4.—Any defect in the gland can be readily remedied, and, being easily accessible, can be maintained much better up to its work, and in a state of efficiency, than the bucket, which, being concealed in its barrel, is difficult of access and inspection.

5.—It has been found that forcing pumps are more capable of dealing with high pressures and lifts than lifting sets.

6.—When the bucket fails in a lifting set, it must to effect repairs be withdrawn ; not so, however, with the plunger pump, as any leakage can be quickly located, and a few turns of the nuts of the gland is all that is necessary.

7.—A plunger working through a stuffing-box does not wear away the sides of the plunger case by continual rubbing, as in the case of buckets in the working barrel, which consequently requires to be bored.

8.—For deep mines plunger pumps are decidedly preferable. If a lifting set was employed, a greater number of lifts would be necessary, entailing greater cost of fixing, repairs, &c.

9.—A minimum of lifts in a shaft will ensure reduced friction, freedom from complications, and the working parts will be simpler.

10.—The rods and connections of a plunger set being exposed to view, any weakness or damage is quickly noticed, and, unlike a lifting set, can be repaired in their place, often avoiding trouble in disconnecting, &c.

11.—The stuffing-box can be made to withstand almost any pressure, and on account of this higher lifts are readily taken, which cannot be said of lifting sets.

Lifting sets would be more suitable for low lifts, in which case they are cheaper than a plunger pump ; also where the shaft bottom is liable to become drowned, they are preferable. Again, in cases where the shaft is being continually deepened, a bucket lift is usually used, because it can be easily lengthened, as desired.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

E. Ambrose, J. A. Withington, Alfred Stephens, Jas. Grundy (*12 marks each*).

John Parkinson (*8 marks*).

Steam.

Q. 6.—*Describe the different stages involved in the conversion of water into superheated steam, carefully noting the changes of temperature and volume.*

A.—I would like to state at the outset that water is a compound substance, consisting of hydrogen and oxygen chemically combined in the proportion of two volumes of hydrogen to one volume of oxygen, written in chemical symbols H_2O. When water is subjected to the action of heat we find it can be converted into steam, which may be termed water in a gaseous state. We find that though a physical change of the substance has taken place the chemical composition of the steam is in no way different from that of the water from which it was generated. We may then define steam as either the vapour of water or a condition of gas produced by superheating of that vapour. When dry it is invisible and transparent like air. The different stages involved in the conversion of water into superheated steam are first saturated steam, and then by the further application of heat we have our superheated stage. Saturated steam may be briefly defined as steam in contact with the water from which it is generated. Steam, when in such a state is at its greatest density, corresponding to the temperature and pressure at which it is formed. Its physical condition is such that at the slightest increase of pressure or decrease of temperature it is ready to yield some portion of liquid. For a given pressure there is one temperature and one density, and consequently one volume. This is the kind of steam which is usually supplied to engines from ordinary boilers. We have in some instances produced what is known as dry, saturated steam by ordinary steam boilers. It is called and known as dry because it contains no water ; saturated because the abstraction of the smallest quantity of heat reduces some of it to water, because when such expands in doing work a portion of it liquefies. We now come to the superheating stage. We defined it previously (superheated steam) as saturated steam which has received an additional quantity of heat after it is freed from contact with the water. In the process of superheating the action of the steam is that of a gas when under the influence of heat ; the steam increases either in volume or in pressure, as it increases in temperature, therefore were the steam "bottled up" in a closed receptacle whilst being reheated, the result would be a rapid increase in pressure. By the application of a superheater, however, the steam has freedom to expand as the heat is added, thus the volume of steam per lb. weight is increased in proportion to the rise in temperature, but the pressure does not rise beyond the pressure of the steam in the boiler, thus proving very advantageous, as the pressure inside a boiler is a very big

item indeed. This allows the steam to be superheated to any extent without increase of pressure. In English practice, however, from 100 to 150° Fah. of superheat is usually provided for in the proportion of superheating surface to boiler heating surface adopted.

I will now cite some matter on steam formed in a boiler from Volume 5 of *Modern Mining Practice*. It states, let water at 32° Fah. be heated in a closed vessel, such as an ordinary steam boiler, containing space for the accumulation of such; and let heat be gradually applied. Then at the commencement the pressure on the surface of the water is usually equal to that of the atmosphere, and the temperature of the water will gradually rise and steam will be formed at 212° Fah. As the heat is increased, the temperature, pressure, and density of the steam increases indefinitely, so long as the strength of the boiler is not exceeded. Therefore under pressure the temperature of water and steam can be raised to any degree. Saturated steam under a given pressure has a fixed temperature; also the temperature and density increase with the pressure. Thus at 14·7lb. per square inch we get steam at 212°F. If we further heat the same the temperature of it in the closed vessel increases, and also its pressure increases. Under this increased pressure we require a greater temperature to cause evaporation. Hence we find that at a pressure of 70lb. per square inch complete evaporation will not occur until the temperature is 302·8°F., thus the pressure of the steam formed will be 70lb. per square inch absolute. During the evaporation period of the water in the closed vessel, or say boiler, work is being continually spent in compressing the steam already formed. For example, at 212°F. and 14·7lb. absolute, 1lb. of steam has a volume of 26·36 cubic feet; but at 302°F. and 70lb. absolute pressure, the volume of 1lb. of steam is compressed to 6·07 cubic feet; at 120lb. pressure absolute it is compressed to 3·65 cubic feet. We have it defined that 1 cubic foot of water when changed into steam at atmospheric pressure occupies a space of 1,642 cubic feet.

For further information on the above matter I refer readers to some tables which are given in *Modern Mining Practice* (Vol. 5, page 80), and COCKIN'S *Coal Mining* (page 228). They give pressure, temperature, volume, and density of steam.

JAS. GRUNDY, Wigan Road, Bryn.

Alfred Stephens, H. P. Smith, A. Nelson (*12 marks each*). E. Ambrose (*8 marks*).

Winding.

Q. 7.—*What is the negative load of a winding engine, and when does it occur?*

A.—The negative load on a winding engine is of great importance in connection with the winding equipment of a mine. It is chiefly due to the fluctuations of the relative weight of the winding rope upon the drum, which accelerates or retards its motion to a degree corresponding to the position of the cages in the shaft. When the full cage is resting upon the bottom of the shaft the rope connected to it will—when the wind is commenced—be in tension, and therefore exert a pull upon the rim of the drum, in a direction *opposite* to the pull of the other rope connected to the empty cage resting or supported at the pit bank. When considering the rope independently of the cages and load the ascending and descending portion will be in a state of equilibrium only when the cages are passing each other in the shaft, *i.e.*, the resultant force at this instant is such as to exactly counteract each individual force. It should be remembered, however, that the above is only applicable and true in cases of uniform size ropes; in tapering ropes the point of equilibrium differs according to the degree of taper, &c. However, the whole gist of the thing lies in the fact that the positive load upon the engine is constantly decreasing, due to the gradual diminution of rope on one side, and the increasing weight on the other side on account of the lengthening of the rope. The result of this variable weight of rope acting firstly against and terminating with—the motion of the engine, is that the engine is required at the start to exert an immense force in order to raise the total weight of rope, cage, and tubs, and towards the end of the wind the horse-power of the engine has to be gradually reduced, until a point is reached whereby the full and empty weights on each side of the drum balance each other. Beyond this point the conditions become such that the descending load due to the weight of rope above it is greater than the ascending full load, the result being that—unless a system of counterbalancing is employed—the engine has to exert a *negative* load, in order to retard the force of the down-going load. Therefore the answer to the first part of the question is—the negative load of a winding engine is that load which effects a retarding action upon the descending load, due to the latter having accumulated such a weight of rope as to overcome the ascending load, and also possesses a surplus which would assist the ordinary working of the engine, unless the latter was reversed.

Suppose we consider the case of a winding equipment with a parallel drum. At the moment of starting the state of balance between the—

Descending Side	lb.	*and* *Ascending Side.*	lb.
Weight of Cage and Trams ..	4400	Weight of Cage and Trams	4400
Coal	0	Coal	6400
Rope	0	Rope	7000
Total ..	4,400	Total ..	17,800

∴ Unbalanced tension = 17,800 — 4,400 = 13,400.

At the termination of the wind the conditions are obviously changed, because during the wind the rope on the rising side is wound up, and an equal quantity unwound on the descending, and in consequence the state of balance struck between the—

Descending Side	lb.	*and* *Ascending Side.*	lb.
Weight of Cage and Trams ..	4400	Weight of Cage and Trams	4400
Coal	0	Coal	6400
Rope	7000	Rope	0
Total ..	11,400	Total ..	10,800

∴ Unbalanced rope tension = 11,400 — 10,800 = 600lb.

By a careful examination of the above we are able to see that at the commencement of a wind there exists a tension of 13,400lb. against the pull of the engine, whilst at the end of the wind there is a pull of 600lb., which assists the engine, therefore the engine must exert a negative or, in other words, a retarding force in order to *hold* the cages, otherwise an overwind occurs.

Of course the answer to the second part of the question may be easily gathered from the foregoing notes. It is only necessary to make it more precise—it occurs when an equalising or counterbalancing arrangement is not employed, and comes into action *towards* the end of the wind.

An unbalanced winding rope creates a very undesirable state of conditions. There prevails a vast expenditure of unnecessary power, inasmuch as we have an expenditure of power during the end of each wind which performs no useful work whatever. Also, the winder must be of such a capacity and strength as to raise the immense weight at the commencement of the wind—in fact, the evils of unbalanced ropes cannot be too much condemned. A compensating winding system is the up-to-date thing.

A. Nelson, Maes-y-Dyffryn, Glyn Neath.

[NOTE.—Seeing that negative means a *minus* quantity or less than nothing we have a negative load on a winding engine when the load is less than nothing, that is to say, when the pull is in the same direction as the drum is revolving. When the loaded cage is at the bottom of the shaft, and the empty, of course, at the top, the pull is against the engine and is equal to the weight of coal *plus* the weight of one rope, and this load has to be raised against gravity by the engine. If the shaft is a deep one, it may happen that the rope is heavier than the coal in the loaded cage, in which case as the latter nears the surface the weight of rope in the shaft descending with the empty cage becomes heavier than the weight of the rope and coal in the ascending cage, and the result is that no resistance whatever is then offered to the engine—in fact, the *negative* load tends to pull the drum round faster, and the engines may run away unless checked

as they generally are by reversing. We may say, therefore, that the negative load occurs as soon as the descending load becomes greater than the ascending load, as it does when the weight of rope descending becomes heavier than the weight of ascending coal and rope. The point where this occurs must of necessity be somewhere near the top of the shaft, because at the meeting the two ropes must be of equal weight, and the weight of coal is still a positive load, so that it must be a considerable distance above the half-way. —C.C.M.]

Alfred Stephens, Jas. Grundy (*12 marks each*).
Jas. A. Withington, E. Ambrose, Cyril Lane (*8 marks each*).

Methods of Working.

Q. 8.—*What special dangers attend pillar workings, and how should they be provided against?*

A.—Taken on the whole pillar and stall workings are more dangerous than long wall. It is usually those seams that are of such a thickness that sufficient packing cannot be obtained to thoroughly pack the goaf that are worked on the pillar system.

In the first working (*i.e.*, the making of the pillars) there is very little danger if the pillars are made large enough. What danger there is lies in the fact that, if the ventilation is not up to a high standard, there will very often be dangerous accumulations of the prevailing gases in the workings. To provide against this, under normal conditions, the usual appliances for ventilating headings (canvas, partitions or pipes) should be kept in a good state of repair, so that sufficient air can reach the headings to thoroughly ventilate them. Anyone entering the headings after an idle period should be wary, especially after having passed the last cut-through, or they might rush into such an accumulation of gas.

The chief dangers attending pillar workings are to be met with during the second working when the pillars made in the first working are being extracted. It is then when roof dangers are to be feared.

When these pillars are being taken out, it is necessary to provide sufficient support for the top, and seeing that this cannot be provided by stowing the waste with *debris*, on account of the scarcity of the latter, timber supports have to be used.

If the whole top was to be supported it would probably not be worth while to work the mine on account of the large timber bill that would have to be met, therefore the supporting of the roof should be confined to the edges of the pillars, and places where men have to work and travel. Under any circumstances timber is but a poor substitute for packing where a large area of roof has to be supported.

When pillars are being taken out the work must be done in a systematic manner. Those pillars farthest from the main haulage road should be the first to be taken out. The roof should be well supported where the work is being done; wooden chocks placed alongside each lift are a good means of support for the goaf edge. As the pillars are being taken out all the back supports should be withdrawn, and the roof in the waste allowed to fall. This saves a large amount of timber, and relieves the pillar edges of a large amount of weight that would be naturally thrown upon the remaining pillars were the roof in the waste allowed to stand. When the roof in the waste will not fall after the supports have been taken out, measures should be taken to make it fall, as the safety of the men working the pillars out depends to a large extent upon it falling. If it does not fall it leaves a large amount of space for the accumulation of gas, in addition to throwing its weight upon the working faces.

Another item worthy of notice is the length of time taken in extracting each pillar. When the taking out of a pillar has commenced the work should proceed as fast as possible until that pillar has all been extracted. This provides new roof for the men to work under. The last piece of any pillar is always most dangerous, and an extra amount of timber should be put in to catch the weight when it is being taken out.

When taking out pillars the roadways into the face should not be taken through any goaf, but along the sides of the pillars.

James A. Withington, 2, Percy Street, High Wheatley Hill, near Thornley, R.S.O.

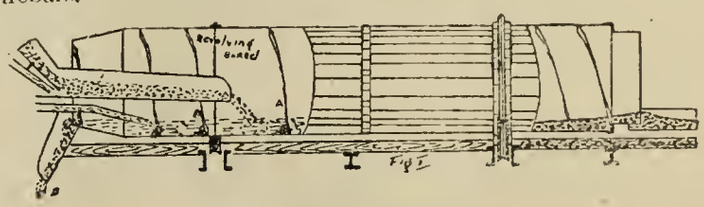
[NOTE.—One of the objections to the working of coal by the bord and pillar or pillar and stall method is based on the danger which is encountered in working out the pillars. No doubt in cutting the stall-roads out there is less danger from falls of roof than there is in working long wall, but the latter is again considerably safer than working out pillars. The danger arises from the fact that in working out pillars we have as a rule no packing dirt with which to support the roof after the coal is removed. We cannot attack a pillar as we would a long wall face, but we must keep taking a rib (as it is called) off it of four or five yards wide, making a liberal use of chocks so as to prevent the roof from falling against the face where we are working. Unless the roof is very strong, it probably will fall before we have removed the whole of the pillar, but if we have carried out our chocking in a proper manner no harm will be done; in fact, it will relieve the pressure at the face, though, of course, this may not help the coal to work any better, though it will increase the safety in working it, and some good packing material may be obtained from the fallen roof.—C.C.M.]

Jas. Grundy, John Parkinson, A. Nelson, E. Ambrose (*12 marks each*).

FIRST CLASS.
Coals.

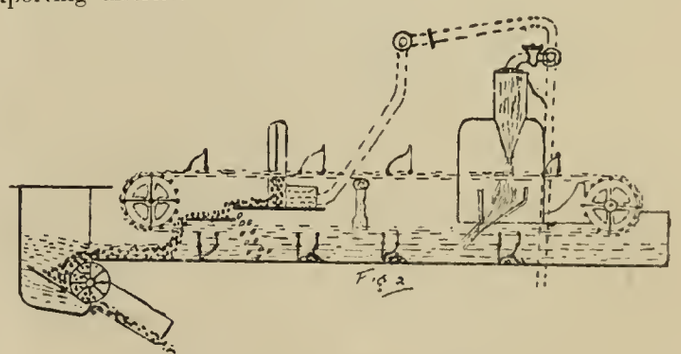
Q. 9.—*What are the qualities required in a steam coal for navigation purposes? Where are such coals found in the United Kingdom, and how are they prepared for sale?*

A.—For navigation purposes we require the best steam coal obtainable, and various analyses have been carried out to ascertain the different percentages in its composition. As its name denotes it is required for steaming purposes. When burning it should give off as little smoke as possible. Its evaporative power should be high, should have as little ash and impurities as possible, should not be ready to coke on the fire, as light burning as possible, and the clinker should not stick to the firebars.



Illustrating Question 9.

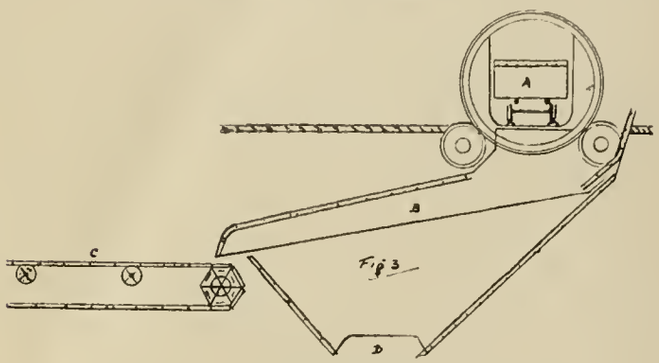
Steam coal is mined in the North of England and South Wales. The best steam coal is mined in South Wales from the White Ash series, which contains very valuable seams of coal of various thickness, varying from three to nine feet and upwards. It is to this series that South Wales owes its position as a coal-exporting district.



Illustrating Question 9.

Practically at all the collieries at the present time coal is specially prepared for the market. On the Continent the treatment of coal at the surface is so keen that we in Great Britain have to conform, or the market value of our coal will decrease. Consumers are now very careful to purchase clean coal free from all dirt, slag, &c., therefore various processes for washing, picking, screening, conveying and tipping, with the minimum

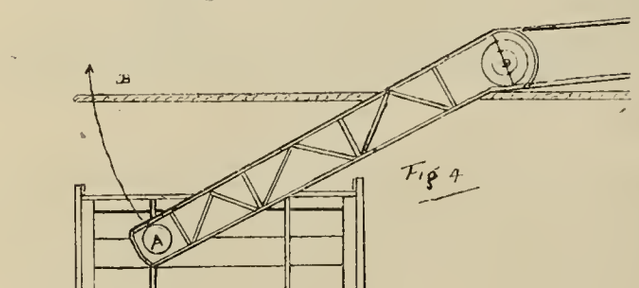
amount of breakage of the coal, have been introduced, and the labour in its preparation has increased. There are many kinds of coal-washing machines in use, some of which are the Primus, Elliott, Blackett, Murton, &c., and they all work on the same principle. The specific gravity of coal being less than that of slag, stone, pyrites, &c., in the presence of moving water the heavier parts fall to the bottom, being conveyed to the rubbish tip by a dirt conveyor, while the coal is conducted to screens to be separated into the required sizes.



Illustrating Question 9.

Figure 1 shows a Blackett coal-washer. It consists of a revolving barrel, to the inside circumference of which is attached a worm or screw *A*. This worm is in a piece with and revolves with the barrel, so that all crushing of the coal is avoided, and only sufficient motion given to the material to allow the dirt to freely separate from the coal. The dirt is conveyed to and discharged from the higher end of the machine at *B*. This refuse, being of greater specific gravity than the coal, is deposited and lies behind the worms *A*, and as the machine revolves is carried in a rotary direction so far up the inside circumference from whence it slides back to the bottom of the barrel.

Figure 2 shows a New Elliott washer. This is of the trough kind, the scrapers of which are driven by single or double endless chains. The coal is sized before it is delivered into the trough, also the fine dust is parted from the larger coal to allow better washing.



Illustrating Question 9.

Figure 3 shows a coal tippler *A*, jigging screen *B*, and conveying belt *C*, and to get clean coal for the market (or in this case for navigation purposes), care must be taken in the first place in tipping. Then it is generally passed inso a double jigging screen, and here it is screened into large coal, cobbles, and smalls. The large coal is passed direct on to the conveying belt *C*, where all dirt, slag, &c., are picked out by men and boys; then it is allowed to pass into the truck. The lower end of the belt or conveyor (*Figure 4*) can be lowered or elevated as needed, so that when the truck is empty the fall for the large coal or cobbles will not be so great, and the less damage is done to the coal. When the truck fills the jib of the conveyor *A* can be elevated to *B*, *Figure 4*, and the truck allowed to move on as required.

The cobbles, which fetch a high price on the market, are either washed or passed on to another conveyor. However, the cobbles are seldom washed, as all the slag is generally picked while it travels on the conveyor.

The smalls which are produced at *D*, *Figure 4*, are screened to get the very fine coal into truck, and what they call peas, beans, nuts, &c., are washed. These are taken from *D*, *Figure 3*, to the washery, where they are washed and screened into their respective sizes.

Other collieries, where they are more fortunate, and the seams of coal are not dirty, need not make such elaborate preparations for the market, as they only part the coal into large, cobbles, and smalls.

The screening plant can be altered to produce any sizes of coal required from time to time.

Indebted to respective manufacturers for sketches.

DAVID MAINWARING, Newlands, Grovesend, near Pontardulais.

D. J. Jones, Walter Heys, Fred Hutchinson (*12 marks each*).

Pumps and Pumping.

Q. 10.—*What arrangements are necessary for renewing the wearing parts of mine pumps, and generally for keeping the pit work in order?*

A.—The arrangements necessary include a strong capstan engine placed on the surface for raising the pipes, &c. Duplicate parts of all the essential parts of the pump (such as rods, pipes, clacks, &c.) should always be kept on hand, together with chains and bolts, and rubber sheeting, rings, packing, &c. There are many ways in which shaft pumps are liable to be damaged.

Figure 1, illustrating Question 10.—Banging Pieces on Pump Rods.

When the pump "strikes on air" the pump rods and engines are liable to two shocks—one by the bucket striking into water below it at some point of its stroke in the barrel; the other by the beam or quadrant coming with great force on the spring beams, known as the "bat," giving the engine and pump rods a shock which may cause a pump rod or some portion of the apparatus to break. To mitigate the results of such accidents "banging pieces" (see *Figure 1*) are provided, and it is better to fasten these projecting catches or banging pieces by strap bolts around the pump rod rather than pass bolts right through the rod. The "striking on air" may be caused by a clack pulling and not sustaining the column of water; by air passing in at a leaky joint, and counteracting the suction, so that there is no water beneath the bucket; or by water in the sump being pumped down. Or it may be caused by failure of the bucket

or clack. A bucket may fail by the leather or other material of the bucket being worn through, cut through, &c., or being drawn downwards over the side of the hoop. When a pump "strikes on air," if the sump bottom is muddy, a quantity of it may be drawn away into the pump and carried up with the water, and should the pumping be stopped with the water in that muddy condition the mud will settle down on the bucket and may choke it. This is one of the dangers to be apprehended from a dirty sump or standage. Another from the same source arises when the dirt and rubbish are allowed to accumulate around the holes in the windbore until they are choked so that the water cannot get freely in. The pump is then said to be "wire drawn," therefore it is necessary to keep the pit bottom clear of dirt, and also have some fence to prevent it flowing about the wind-bore piece. Accidents may arise from a split pump band or a split pipe in the column; this may be caused by great pressure and defective material. A working barrel is also subject to wear and damage. One very frequent source of injury is caused by nuts, bolts, and splinters of wood detached from the pump rods pulling on the bucket and becoming wedged between the bucket and the barrel, cutting grooves in the barrel and destroying the bucket leathers. The barrel is then said to be "fluted." A bucket may soon be so wedged that it is immovable; then the column of pipes must be broken and raised, the rods disjointed and cut, and the working barrel brought to the surface for the removal of the bucket. This shows the necessity of having not only regular examination

Slightly indebted to BAILE'S *Mining*, and "Notes from Wales" by BRYCHAN.

F. HUTCHINSON, 27, Longfield Road, St. Helens Road, Bolton.

Robert M. Lewis, Walter Heys (*12 marks each*).

Spontaneous Combustion.

Q. 11.—*When a coal seam is on fire underground, how should it be isolated to prevent the fire from spreading to other parts of the workings?*

A.—The situation and extent of the fire and the relative position of the roads, must necessarily determine the plan adopted for isolating the fire. Circumstances vary with each individual case, but experience and theory have caused it to be desirable to erect the first stopping in the return air-way. Especially is this the case when the burning area contains fire-damp. The reason is that when the return air-way is closed first and the other stoppings sealed up from the return towards the intake the outlet for the smoke and gases is closed, and the products of combustion are held back, and become mixed with the air that makes its way to the seat of the fire. Since they do not support combustion those products aid in extinguishing the fire and prevent the formation of explosive mixtures, or cause explosive mixtures to be rendered inexplosive. Consequently, if a liberation of fire-damp occurs within the

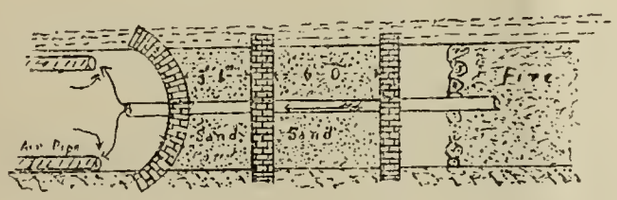


Fig 1 Method of Damming back Mine Fire

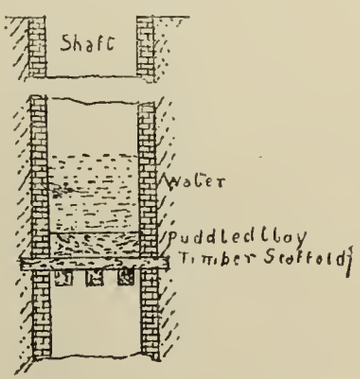


Fig 2 Dam fixed in Shaft

Illustrating Question 11.

made, but also having the spear rods drawn out and thoroughly overhauled. Another danger to a pump is when small pieces of wood get afloat on the water and are drawn into the pump and then get into the clack or bucket. This is called a "gag" or "snack" in the clack or bucket. A broken pump rod may happen from the pump going beyond its stroke, and causing severe strain on the rods. In underground pumping engines subject to great pressure, failure of the valves may result from great strain.

Other points which tend to keep a pump in good working order are not to place the working barrel too far above the water in the lodge. The best results possible will be attained with a height of about 18 feet. Frequent examinations of the pipes and rods should be carefully made. If the rods were outside the pipe, I should have them examined once a week. To do this two men should slowly descend on the cage, and with the aid of hand hammers test the bolts and plates of the joints, and carefully examine them. The connections at the top and bottom require special attention. If the rods were inside the pipes I should have an examination made every three months, or oftener if the class of water being pumped required it. The rods withdrawn as stated above, an engine or winch being provided for raising them. The greatest stress on pump rods is at the upper end near the engine, and least near the bottom set of pumps. The rods should therefore decrease in section as they descend. This is done in some cases, and where not done it is because of the convenience of having a spare length which will fit in anywhere. Needless to say, they should be of uniform length and as long as is compatible with convenience in handling.

burning area, and tends to form explosive mixtures with the incoming air, this tendency is neutralised by the combustion products. Further, the pressure of the intake current causes the smoke and fumes to be pent up and held back, and this permits the building of the intake stopping with a supply of fresh air. On the other hand, if the intake air-way is closed first, and the products of combustion are allowed to escape without restriction, their lightness allows them to escape readily, whilst the air in the burning area may become charged with fire-damp, and the formation of an explosive mixture results. In addition the products of combustion will flow towards the return passage, and render it dangerous and even impossible to completely dam it off.

Having these things in mind, I should start building the first stopping in the return air-way as follows: All small coal and dirt should be carefully removed, the ground levelled down, and the floor and sides cut out to a depth of at least two feet. The stoppings should be perfectly air-tight. In such case there should be two well and substantially built walls, 3 feet thick and 6 feet apart, and the intervening space filled with dry sand well rammed. Where there is any likelihood of an explosion of inflammable gas, in addition to the two walls above a third wall should be built with a convex surface, the convex surface being placed nearest the fire so as to resist internal pressure if necessary. While building the dams it must be borne in mind that the fire will burn for a considerable time after the sealing of the dams, and the pent up gases will exert an enormous pressure upon the dams. To guard against any damage resulting to the dam from this cause, a relief pipe

fitted with a screw stopper and pressure gauge is built into the dam. The four walls of the dam should be carefully and frequently examined, and any defects due to movement of strata, or construction, or the natural consequence of the heat, should be quickly made good, as if all leakages are not avoided the fire may be left smouldering, and break out again with even greater intensity on the reopening of the stoppings.

During the building of the dams it is necessary that as much air as possible should be kept away from the vicinity of the fire, and yet it is necessary that an adequate amount of fresh air be kept for the men at work. In order to do this I should use air-pipes (see *Figure 1*), the pipes being the return, and kept a short distance ahead of the men. By this method the men are always working in pure air, the gaseous products being exhausted directly into the return.

The men engaged in stopping off the fire should work with safety-lamps, and a deputy should always be left in charge of the workmen who understands gases and the methods of rendering aid to men overcome by irrespirable gases. A good plan is to have two or three sets of men, one relieving the other at intervals, the party relieved resting in fresh air. Then should any person or persons be overcome by the smoke and fumes, the party resting is at hand to render assistance.

If the mine gives off large quantities of explosive gas, it is best to seal off that part of the mine, or all the mine, by building impervious dams (see *Figure 2*), in the shafts, and abandon the mine for some months.

Indebted to *Modern Mining Practice* by G. M. Baile for some assistance in compiling this answer.

Fred Hutchinson, 27, Longfield Road, St. Helens Road, Bolton.

Walter Heys, W. Silverwood, R. M. Lewis (*12 marks each*). D. J. Jones (*8 marks*).

Surveying.

Q. 12.—*What errors in direction are likely to arise from surveys made with the magnetic needle, and how can such errors be controlled and corrected?*

A.—Surveys made with the magnetic needle are often incorrect owing to the influence of metallic substances upon the needle of the instrument. It is a well-known fact that iron and steel will influence any magnetic needle if brought into close proximity with it, and as a result one end of the needle is attracted towards the metallic substance. It is obvious that owing to the deviation of the needle from the north line due to local attraction a true observation cannot be made. This to say the least, when surveying with the magnetic needle pure and simple, is a source of difficulty and hindrance. Many metallic substances necessary to mining operations will be met with during a survey, notably iron and steel rails, girders, flats, iron and steel tubs, ropes, chains, tools, &c., and it would be an utter impossibility to remove these to such a distance as to make it impossible for them to influence the needle. Of course, in many cases they can be easily removed, and where it is safe to do so they are removed to a distance of from 4 to 8 yards, according to the sensitiveness of the needle and the mass of iron.

In most cases it is not desirable to remove the metallic substance, and in such cases the needle is sure to be deflected from its proper direction. A correct or practically a correct survey may be made with the magnetic needle alone in the presence of iron or steel provided one correct bearing is obtainable. Briefly speaking, in this method every bearing has to be corrected, *i.e.*, reduced or increased according to the direction which the deflection has taken before the reading, which of course would have been obtained had there been no local attraction. In his *Colliery Surveying*, T. A. O'Donahue gives an illustration of this method of surveying, which he terms the method of "correcting deflection," this method being adopted to control and correct errors as stated in the question.

A place is found at or near the beginning of the survey where the needle is free to assume a position unaffected by the presence of iron or steel. The instrument is fixed and a bearing taken towards *B*, the instrument being set up at *A*. The bearing is read off, and is found to be N50W. As there is no attraction on the needle this is booked as a correct bearing, and the remaining bearing of the roads must be calculated from this. The dial is removed and fixed at *B*, and a back bearing is taken towards *A*. This should read N59W, as it is in the same line of sight that was previously taken, but owing to the local attraction the bearing is found to read N47W, *i.e.*, the needle has been attracted 3°N of its true course. A fore sight is taken to *C*, and the bearing reads N48W. Since the dial has not been disturbed the correct bearing is N48W + 3 = N51W. The instrument is now removed to *C*, and a back sight is taken to *B*. This is found to read N53W, therefore the needle has been deflected 2°W. A fore sight is taken to *D*, and the bearing is read off as N56W, but as the direction is the same as was previously ascertained by the back sight the correct bearing is N54W. If the instrument is then placed at *D*, and the needle is free from disturbance, a back sight to *C* should give the bearing N54W, and a check on the work is thus obtained, the work being then tied in. Errors can also be controlled and corrected by the use of the "racking" method of surveying. This is so especially when surveying say on a lengthy haulage road. In this case I should obtain a loose needle bearing at the commencement of the survey if practicable, and also one at the finish. Between these two intermediate points "racking" must be practised. Great care should be taken with the "racking," as any error is carried forward and multiplied throughout the survey, so that I should take intermediate loose needle bearings wherever possible, and so check any errors which may arise during the course of the survey.

Errors may arise through the secular variation of the magnetic needle, and allowances must always be made for these, the magnetic meridian being obtained for all important surveys.

The magnetic needle is also subject to irregular variations, such as those due to magnetic storms, local earthquakes, &c. Errors can only be controlled and corrected in one way when due to this cause, and that is by making a new survey.

Errors also arise owing to the needle being sluggish, or sticking on the pivot point or to the underside of the glass. A sluggish needle is utterly useless, and must be replaced, the test being made by means of bringing a metallic substance near the dial at various points. When withdrawn the needle should always return to its former position.

When the needle sticks the glass should be smartly rapped and the movement of the needle carefully watched, as errors may easily arise from this cause.

If the centre pin or pivot is not exactly in the centre of the needle different readings are obtained from the separate ends of the needle. In this case errors are controlled and corrected by reading both ends of the needle, and by then taking the mean or average of the two.

Walter Heys, 1, Walter Street, Huncoat, Accrington.

[Note.—Practically the only way to control and correct errors arising in making surveys with the magnetic needle is to obtain at least one bearing which we can be certain is uninfluenced by magnetic attraction. This really requires at least two such bearings, as it is impossible to say with certainty that any loose needle reading at one point is correct unless it agrees with another reading taken at another point. The method of loose needle surveying described above in which we start off with a correct loose needle reading and allow for any error which may be present at any of the subsequent fixings is a method which we have never seen employed underground, though we have used it once on the surface, more out of curiosity than anything else. It can be employed with a fair amount of accuracy, but we see no advantage in it over the method of fast needle surveying with a correct needle reading as base line, except in the case of a dial without a vernier, in which case if we wished to survey a road with rails down we should have to adopt the loose needle method described above.—C.C.M.]

W. Silverwood, Fred Hutchinson (*12 marks each*). A. J. Johnson (*8 marks*).

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